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PREFACE

Environmental Outlook 1978/79 was produced to provide quantitative information on environmental quality trends for the Agency's Research Outlook report, the comprehensive five-year environmental research and development plan which the Agency is required to submit to the Congress each year. Dr. Richard Ball, now Branch Chief, Methods and Data Evaluation Branch, Environmental Impacts Division, U.S. Department of Energy, was Project Officer for this report. The three scenarios used to structure the analysis were constructed and analyzed by International Research and Technology Corporation, McLean, Virginia, and Urban Systems Research and Engineering, Incorporated, Cambridge, Massachusetts. Contractor personnel on this project were: Richard K. Meyers, Don S. Cooper, Ralph Doggett, Mark Heller, and Richard Reither of International Research and Technology; Peter Hall, Carol Blair, and Chang Tang of Urban Systems Research and Engineering.

Inquiries concerning the report should be addressed to the Strategic Analysis Group, Office of Research and Development, U.S. Environmental Protection Agency.

ABSTRACT

Projections of pollutants produced and released to air and to bodies of water, by Federal Region, from 1975 to 1990 are presented and discussed in this report. These are projections of the Strategic Environmental Assessment System (SEAS), which is a computer model consisting of a detailed sector by sector economic model, and a set of emission coefficients describing regulated levels of control of each industrial sector and region. The conventional air pollutants treated include particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Point source water pollutants treated include suspended solids, dissolved solids, oil and grease, biochemical oxygen demand, and chemical oxygen demand. Certain cases of toxics discharged to air and water from a list of beryllium, cadmium, manganese, nickel, and selenium are also included. The projections are driven by three sets of energy and GNP growth assumptions, spanning from 2.8 percent per year to 3.7 percent per year GNP growth. An interpretation of the National Energy Plan I is used as the set of high growth assumptions.

Validation of base year estimates are attempted by comparing them to EPA NEDS data. All projections should be treated as rough approximations given a set of scenario assumptions.

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EXECUTIVE SUMMARY

The purpose of this report is to provide quantitative information on environmental trends as a guide to better planning of Federal research and development activities. The Environmental Outlook supports annual revision of the Research Outlook, a comprehensive five-year plan for Federal environmental R&D mandated by Sections of Public Law 94-475.

Important environmental trends have been identified through use of a long range forecasting model, the Strategic Environmental Assessment System (SEAS). The SEAS system is composed of a set of interdependent computer programs that forecast interactions among major economic, energy, and environmental variables. In this case, SEAS was used to estimate regional and national emissions of key air and water pollutants generated by 185 sectors of the U.S. economy in 1985 and 1990.

SEAS projections are sensitive to the sets of assumptions (scenarios) about economic, energy use, and regulatory conditions made at the outset. Three distinct scenarios were tested and their environmental consequences analyzed in this report. The Baseline scenario represents a future of fairly high economic growth (about 4 percent per year) and moderate energy conservation. The Low Economic Growth scenario assumes much slower growth in GNP and population. High fuel prices stimulate investments in energy conservation measures, but slow economic growth restricts the ability of industry to invest in new production processes. The NEP scenario (a simulation of the 1977 National Energy Plan) assumes rates of growth for GNP and overall energy use similar to the Baseline case, except that a higher rate of substitution of coal for petroleum and natural gas is assumed. The following paragraphs summarize key regional and national environmental trends that result from the assumptions of these scenarios.

Air Quality

Emissions of particulates are projected to decline in all scenarios by 1990 to between 58 and 66 percent of the 1975 value. This reduction is attributable to required improvements in abatement practices, achieved mainly prior to 1985. After 1985, the trend in particulate emissions will turn upward, reflecting continued economic growth. This pattern is repeated in most federal regions. Slight increases in total emissions are projected for Regions I (New England) and VI (South Central) by 1990. The greatest projected reductions are achieved in Regions III (Middle Atlantic) and V (Great Lakes), due to controls on existing coal burning facilities.

Sulfur oxides are projected in all scenarios to decline slightly over the forecast period. As in the case of particulates, sulfur oxide reductions are achieved during the 1975 to 1985 period, and total emissions will again increase by 1990. The regional picture is less clear. Region IX (West) is projected to achieve a 40 percent reduction of sulfur oxide emissions between 1975 and 1990, while Regions IV (Southeast), VI (South Central), VII (Mountain), and X (Northwest) exhibit net increases. Region VI emissions are projected to increase by 94 percent during this period.

Nitrogen oxides are a major exception to the general improvement in air quality indicated by SEAS. All three scenarios result in 1990 emissions that are 110 to 130 percent higher than the 1975 reference value. Major increases are expected from truck travel, industrial and utility combustion of coal, and petroleum refining and storage. However, a major reduction is forecast for nitrogen oxides from automobiles. Regional increases are very similar across the nation, except for a relatively large percent increase observed in Region VIII (Mountain).

Substantial reductions of hydrocarbons emissions are forecast for 1985 and 1990 under the assumptions of all three scenarios. The largest reductions are achieved in steel production, auto travel, and municipal sewage incineration. Growth of emissions is seen in the organic chemicals industry, and in petroleum refining and storage. Reduction in total hydrocarbons emissions is seen rather uniformly in all regions, with the trend between 1985 and 1990 continuing downward or just stabilizing.

Net carbon monoxide emissions decline by about one-half in all three scenarios between 1975 and 1990. Major emissions decreases are projected in the auto travel sector and municipal sewage incineration. Regional trends uniformly mirror the national trend.

Water Quality

Projections and analysis of water pollutant discharges include consideration of dissolved solids, suspended solids, oil and grease, biochemical oxygen demand, and chemical oxygen demand. Only dissolved solids and oil and grease are projected to increase between 1975 and 1990.

A 45 percent increase in dissolved solids forecast by 1990 is attributable mainly to increased coal production and use and increased discharges by the organic chemicals industry. Regional trends generally follow the national trend, with the least net increase (10 percent) in Region II (New York-New Jersey) and the greatest (90 percent) in Regions VI and X (South Central and Northwest). However, the sources of dissolved solids vary between regions.

Major reduction of suspended solids discharge is achieved over the forecast period in all three scenarios. In each case, the major reduction (to about 25 percent of the 1975 level) is achieved by 1985, with very slight increases between 1985 and 1990. These increases are attributable to continued economic growth with no further gains in the efficiency of suspended solids removal.

Similar reductions occur rather uniformly across the U.S., but for reasons that vary from region to region. In 1975, municipal sewage treatment was the major source of suspended solids in Regions I, II, VII and IX, while other industries are the predominant sources in other regions. As such industrial sources come under strict control, major improvements in suspended solids discharge will be realized. This will leave municipal sewage treatment as the predominant suspended solids source in all regions except Region IV, where textiles will remain most important.

The upward trend in discharges of oil and grease is reversed under NEP and Low Economic Growth assumptions between 1975 and 1985, and is depressed during the same period under Baseline scenario assumptions. This is attributed to increasing removal efficiencies attained by industry, with radical improvements in steel and meat products processing. Less improvement is expected in the organic chemicals industry, which accounts for almost 80 percent of total 1975 oil and grease discharge. Consequently, 1990 discharges are forecast to be 102 to 128 percent of 1975 amounts, with the organic chemicals industry then contributing about 90 percent of all oil and grease discharges.

Regional trends in oil and grease discharges reflect the 1975 regional distribution of major contributors: organic chemicals, steel, and meat products processing. Region VI (South Central) is the major regional contributor to oil and grease discharges (27 percent in 1975 and 34 percent in 1990), reflecting the concentration of organic chemicals manufacturing in that region. Large increases relative to 1975 discharge values are projected for Regions I, II, IV, VI, IX, and X, with gains over the 1975 to 1990 period registered only in Regions III and VII.

Significant reduction in discharges of substances exhibiting biochemical oxygen demand are forecast in all three scenarios. As great as 90 percent reductions are forecast in the meat products processing, organic chemicals, and sugar refining industries by 1990, with major reductions in discharges by the pulp and paper industry.

The major source in 1975, municipal sewage effluents, cuts its discharges of biochemical oxygen demand by 20 percent in the forecast period, but increases its relative share of the total in all scenarios. The only net increase in discharge of biochemical oxygen demand is observed in the textile industry, which increases its share relative to other sectors by 10 percent.

Regional trends in biochemical oxygen demand reflect differences in the location of major sources. Over 70 percent of all textile industry effluents are discharged in Region IV (Southeast). Regions III, IV, and IX together account for 90 percent of textile industry discharges. Net regional discharges are rising in 1990, but are below 1975 levels for all regions.

Chemical oxygen demand discharges decline over the forecast period by 10 percent in the NEP scenario, 20 percent in the Baseline Scenario, and 30 percent in the Low Economic Growth scenario. In each case, discharges are minimized by application of effluent controls by 1985, but are rising sharply in step with economic growth by 1990. Declines in all industrial sectors are countered by a doubling of discharges from coal-fired electric utilities. Discharges of chemical oxygen demand by the textile industry decline only slightly over the prediction period, and the industry maintains its approximate 70 percent share of the total throughout.

Region IV (Southeast) accounts for about 60 percent of the total discharge of chemical oxygen demand from 1975 to 1990, owing primarily to the concentration of textile production there. However, gradual shifts in textile activity away from Regions I and IV will reduce the national shares of these regions. Over a longer period, the relative importance of coal-fired utilities in determining total and relative discharges will increase.

Toxic Substances

SEAS toxic substances data bases are incomplete, and forecasts do not reflect the contributions of such sources as the iron and steel industry, and chemicals, paint and ink manufacturing. SEAS projections indicate general increases in atmospheric emissions of toxics, and a general decline in discharges to water. However, air emissions of beryllium, manganese, and nickel will decline, while discharges of selenium to water will increase.

Major contributors to increased toxics emissions to the atmosphere are nonferrous metals production, older oil-fired industrial boilers, and municipal refuse and sewage sludge incinerators. Efficiency gains in control of new coal-fired industrial and utility boilers will more than offset growth in the use of coal, resulting in reduced net toxics emissions from these sources.

Growth in net discharge of toxics is expected in the aluminum industry, lead and zinc production, organic chemicals manufacture, and coal preparation. Coal cleaning will result in higher net discharges of manganese, nickel and zinc to surface waters, while development of synthetic fuels from coal could result in a sharp increase in the discharge of cyanide.

1.0 INTRODUCTION

The Environmental Protection Agency (EPA) is required by law to submit to Congress an annual comprehensive five year research and development plan, called the Research Outlook[1]. The Environmental Outlook is prepared to provide quantitative support for the development of this five year plan within EPA's Office of Research and Development (ORD).

Included in this report is an analysis of the environmental trends which may be anticipated to follow from three alternative futures representing a range of energy consumption and economic growth patterns through 1990. These environmental trends are analyzed at both national and regional levels. The purpose of the analysis is to identify potential future environmental problems and to specify principal demographic and policy variables that can influence environmental trends over time.

The three environmental futures, or scenarios, have been analyzed within the framework of a long range forecasting model, the Strategic Environmental Assessment System (SEAS). This model, initially developed by EPA, is maintained jointly by the Agency and the Department of Energy (DOE). The following two sections briefly describe the major assumptions of the scenarios and the structure of the SEAS model.

1.1 Environmental Outlook Scenarios

The three scenarios developed in this report contain alternative projections of economic output, energy use, and government policy from 1975 to 1990. These scenarios are labeled as follows:

- Baseline scenario
- Low Economic Growth (LEG) scenario
- National Energy Plan (NEP) scenario

The Baseline scenario represents a future of fairly high macroeconomic growth with moderate implementation of energy conservation measures. Total energy consumption increases at only 2.0 percent per year, or about 40 percent less than the growth in GNP, due to energy conservation measures. The supply strategy selected to meet baseline scenario energy demand is a mixed approach. It assumes an increase in use of coal and nuclear energy, and some substitution of these for natural gas and petroleum products. A small portion of total energy use would be supplied by innovative technologies such as coal gasification, coal liquefaction, oil shale conversion, and solar heating. On the regional level, the Baseline case assumes gradual shifts in population and manufacturing locations away from the Northeast to the "sun belt" regions of the country (the Gulf Coast, South, and Southwest).

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[1] Section 5 of PL 94-475, Environmental Research Development and Demonstration Authorization Act of 1976.

The Low Economic Growth (LEG) scenario represents a less optimistic view of national economic prospects. Both GNP and population increase at slower rates during the forecast period, resulting in 1990 estimates that are 14.1 percent and 3.9 percent lower, respectively, than the Baseline case values. These effects are strongly linked to the assumption that energy prices increase rapidly. Although fuel price changes are assumed to stimulate investments in energy conservation measures, the more stagnant economic conditions in LEG restrict industry's ability to invest in new production processes. Since overall energy demands are lower, the penetration of innovative supply technologies is minimal, and oil and natural gas continue to provide a larger share of fuel consumption. Given the overall reduction in capacity expansion and the lower exploitation of western coal and oil shale resources, shifts in the regional distribution of economic activity over time are less pronounced than in the Baseline case.

The third scenario is a simulation of the 1977 National Energy Plan (NEP) developed by the Project Independence Evaluation System (PIES) and Brookhaven National Laboratories. This scenario, examined in the 1977 Environmental Outlook report, was selected to provide continuity with last year's analysis.[1,2] The NEP scenario assumes rates of growth for GNP and overall energy use similar to the Baseline case; however, NEP assumes a much greater rate of substitution of coal for petroleum and natural gas in almost all sectors, particularly in industry. This supply strategy requires larger amounts of new equipment investment and government support than the Baseline case, reducing the portion of GNP available for personal consumption expenditures. The shift in the mix of goods and services and increase in coal consumption would affect the generation of air and

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[1] Residual projections made for the NEP scenario in this year's report will differ from last year's due to updates in the residual coefficient data base and improvements made in the SEAS procedures for regionalizing electric utilities, industrial boilers, and coal mining activity.

[2] Office of Research and Development. Environmental Outlook, 1977. U.S. Environmental Protection Agency, Washington, D.C., July 1978.

required to construct the necessary additions to energy production capacity. This forecast is then fed back to INFORUM and the economic projections are modified.

Estimates of pollutants are generated in a similar manner. SEAS provides projections of conventional air, land, and water pollutants and toxic substances, examining stationary, mobile, and some nonpoint emission sources. Residual generation rates for a given activity are assumed to be a function of the sector's output, gross emission coefficients, and the efficiency of in-place pollution control devices. The latter two factors are calculated for each region, to account for local differences in environmental standards or differences in the input materials used.

The environmental outlook for the U.S. and for particular regions depends greatly on economic growth rates and energy policies. Since these are somewhat variable, this report analyzes conditions within a range of likely futures. By changing certain assumptions and parameters in SEAS, changes in key factors can be examined in a consistent manner. Trends identified in SEAS emission forecasts are related to indicators of existing air and water quality. The impact of changes in emission levels on critical subregions of the country, such as nonattainment areas, Class I (pristine) areas, and Water Quality Limited (WQL) regions, is also assessed. In future versions of this report, these capacities will be extended to enhance the regional analysis.

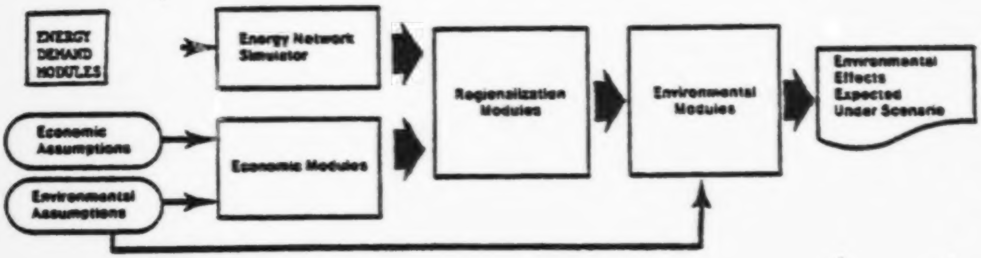
ENERGY DEMAND MODULES
Energy Network Simulator
Economic Assumptions
Economic Modules
Environmental Assumptions
Regionalization Modules
Environmental Modules
Environmental Effects Expected Under Scenario

FIGURE 1
THE BASIC SEAS METHODOLOGY

water pollution. Regional shifts in the location of energy production facilities and related infrastructure would also occur.

Tables I through V summarize the basic assumptions for each scenario regarding economic and demographic variables, energy demand and supply, electric utilities, and environmental standards.

1.2 The SEAS Model

The SEAS system is composed of a set of interdependent computer programs that define and forecast the interactions among major economic, energy and environmental variables. Overall, the model serves primarily as an accounting framework, providing mechanisms for quantifying the primary and indirect impacts of alternate actions. SEAS can make projections over a 25 year period on national levels and at regional levels including states, AQCRs, and SMSAs . The individual modules of the system contribute flexibility for examining the implications of a wide array of policy related questions concerning energy conservation, fuel switching potential, penetration of new technologies, and timing and stringency of pollution control standards.

Figure 1 shows the flow of information through the SEAS structure. Most applications of the model begin with a projection of national macroeconomic and industry level output derived from the University of Maryland's Interindustry Forecasting Model (INFORUM). INFORUM is a 185 sector input-output formulation of the American economy that uses a set of dynamic, time dependent inter-industry coefficients and exogenously specified values for labor force participation, target unemployment rates, and average levels of per capita disposable income as the basis for its forecasts. When the detail provided by INFORUM is insufficient for an examination of environmental or energy related questions (e.g. industrial chemicals), additional commodity forecasting equations are developed and linked to the INFORUM structure.

Energy strategies are analyzed after the initial economic forecast. Three demand modules (industrial, transportation, and residential and commercial energy users) use INFORUM estimates in conjunction with fuel-specific energy coefficients to calculate fuel demand (Btus) for a given year. These modules contain parameters to reflect assumptions about conservation measures, the impacts of fuel prices on demand, and policies toward fuel substitution. The demand forecasts are translated into requirements for resource extraction through the Energy System Network Simulator (ESNS), an accounting framework that shows the technological alternatives that exist at each processing step in the supply structure. After the user selects a supply strategy, ESNS estimates the amount and mix of capital goods

TABLE I

MAJOR ECONOMIC AND DEMOGRAPHIC ASSUMPTIONS OF THE ENVIRONMENTAL OUTLOOK SCENARIOS

	Baseline	Low Economic Growth	National Energy Plan
Rates of Growth (Percent/Year)			
GNP			
1975-85*	4.3	3.0	4.5
1985-90	3.0	2.7	3.0
Per Capita Disposable Income			
1975-85	4.5	2.5	4.5
1985-90	2.2	2.0	2.2
Population			
1975-85	0.9	0.7	0.9
1985-90	0.9	0.6	0.9
Components of 1990 GNP ($billions)			
Personal Consumption Expenditure (PCE)	1,380	1,120	1,360
Gross Private Domestic Investment	330	320	360
Government Spending	370	330	410
Net Foreign Trade**	24	40	5
Total GNP	2,104	1,810	2,140

*Growth rates for this period are subject to some doubt since the 1975 economic outputs reflect the negative implications of that year's recession.

**Exports - Imports

TABLE II

ASSUMPTIONS RELATED TO ENERGY DEMAND

	Baseline		Low Economic Growth		National Energy Plan
Percent reduction in energy/ output ratios for overall manufacturing, 1975-1900	22		18		Not Given*
Percent annual retirement rate for old industrial facilities	1.5		1.2		1.5
Level of incentives for substituting coal for oil and natural gas	Moderate		Low		High
Crude oil price index, 1990 (1972 = 1.0)	9.3		13		Not Given*
Percent splits for passenger travel (1990):	Urban	Rural	Urban	Rural	Not Given*
Auto	88	80	57	79	
Bus	7	2	23	4	
Rail	5	1	16	4	
Air	----	17	----	14	
Automobile fuel efficiency (mpg)	28		28		Not Given*
Percent annual retirement rate for existing housing stock	2.0		1.5		2.0
Percent annual retirement rate for existing commercial facilities	1.0		0.7		1.0
Percent of residential fuel use supplied by:	1972	1990	1990		1990
Natural Gas	53	49	48		46
Oil	31	23	26		27
Electricity	14	27	25		29
Coal	2	1	2		0
Percent of commercial fuel use supplied by:	1972	1990	1990		1990
Natural Gas	38	32	31		36
Oil	25	23	24		20
Electricity	34	43	41		44
Coal	2	3	3		0

---

*The NEP demand forecasts are taken directly from the PIES output, and do not indicate values for these parameters.

TABLE III

ASSUMPTIONS RELATED TO ENERGY SUPPLY

	Baseline		Low Economic Growth		National Energy Plan	
Total Resource Requirements, 1990 (10^{15} Btus)						
Coal	32	33	25	29	37	37
Oil	38	39	31	37	34	34
Natural Gas	19	20	20	24	17	17
Uranium	9.0	9	8.9	11	12	12
Total Energy Consumption (10^{15} Btus)	98		84		99	
Sources of Domestic Coal (10^{15} Btus)	1975	1990	1990		1990	
Eastern Underground	7	11	11		19	
Eastern Strip	6	8	7		8	
Western Underground	<1	3	1		1	
Western Strip	2	11	6		10	
Level of Oil Imports, 1990 (10^{15} Btus)	15		11		14	
1990 Output of Synthetic Fuels: (10^{15} Btus)						
Coal Gasification	1		1		1	
Coal Liquefaction	<1		<1		0	
Oil Shale	2		<1		1	

TABLE IV

ELECTRIC UTILITY SECTOR ASSUMPTIONS

	Baseline				Low Economic Growth		National Energy Plan	
1. Total Electric Demand (10^{15} Btus)	1975 6.5 1985 10 1990 12				1985 10 1990 11		1985 10 1990 13	
2. Fuel Mixes Consumed in Power Generation*	1975		1990		1990		1990	
	10^{15} Btus	Percent	10^{15} Btus	Percent	10^{15} Btus	Percent	10^{15} Btus	Percent
Coal	3.0	45	6.4	54	5.0	46	6.1	49
Oil	1.0	16	0.7	6	0.9	8	0.5	4
Natural Gas	0.9	14	0.2	2	0.4	4	0.3	2
Nuclear	0.6	9	3.1	26	3.0	28	4.1	3
Hydroelectric	1.0	16	1.1	9	1.1	10	1.1	9
Unconventional	0	<1	0.3	3	0.5	4	0.5	4

*Measured in terms of net electricity output.

TABLE V

ASSUMPTIONS OF TIMING AND STRINGENCY OF POLLUTION CONTROL REGULATIONS

Category of Standard	Media Affected	Applicability	Initially Promulgated Compliance Date	Assumed Compliance Date for Full Enforcement
State Implementation Plans (SIPS)	Air	Existing plants. Standards are state specific.	1975	1985
New Source Performance Standards (NSPS)	Air	New plants; national in scope.	1975	1975
Best Available Control Technology (BACT)	Air	Modified forms of NSPS recommended in the 1977 CAA for boilers and utilities.	1981 - boilers 1984 - utilities	1981 - boilers 1984 - utilities
Best Practicable Technology (BPT)	Water	Existing plants; national in scope.	1978	1978
Best Available Technology (BAT)	Water	Existing plants; national in scope.	1984	Requirements waived for a number of industries indefinitely; 1984 date met by others.
Best Available Demonstrated Technology (BADT)	Water	New plants; national in scope.	1974	1974
Regulations on Prevention of Significant Deterioration (PSD) and Class I (pristine) Areas	Air	Region-specific for given AQCRs or county portions.	Case by case	Can be accounted for implicitly within the siting algorithms of SEAS.

Note: Promulgation and enforcement of standards are assumed to be the same in all three scenarios.

2.0 ANALYSIS OF CONVENTIONAL AIR POLLUTANT EMISSIONS

2.1 General

Despite recent improvements in the nation's ambient air quality,[1] air pollution levels, particularly in large urban areas, remain a threat to health and welfare. Nearly all large metropolitan areas violate air quality standards, particularly those for carbon monoxide and oxidants.[2]

This section develops forecasts for five criteria air pollutants to the year 1990, under each of the three scenarios described earlier. These pollutants are particulates, sulfur oxides, nitrogen oxides, hydrocarbons, and carbon monoxide. Forecasts identify significant national and regional trends, and identify major contributors of emissions. Validation of SEAS estimates is described in Appendix A.

Each of the separate regional analyses contrasts regional and national trends (See Figure 2). In regions which are major contributors to the total national emissions or show substantial change over time, the mix of pollutant sources in the region and the major variables influencing the change are described.

There are limitations to this approach of regional analysis. As the current direction of pollution control regulations illustrates, air quality problems and issues may be localized, dealing with individual counties or portions of counties. Long range projections of industrial activity at this level of detail would be highly speculative, and they have not been attempted here. Also, this analysis does not consider questions of long range pollutant transportation, or interactions among pollutants. Consequently, the federal region trends discussed here provide a general indication of future air quality problems.

2.2 National Cross Scenario Comparisons of Forecasts of Air Residuals

This section compares the Baseline, NEP, and Low Economic Growth (LEG) forecasts of emission levels of the five criteria air pollutants. Estimates of pollutant loadings are made for 1975 (base year), 1985, and 1990.

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[1] Council on Environmental Quality. Environmental Quality -- 1977. Executive Office of the President, U.S. GPO, Washington, D.C., December 1977.

[2] Ibid, p. 151.

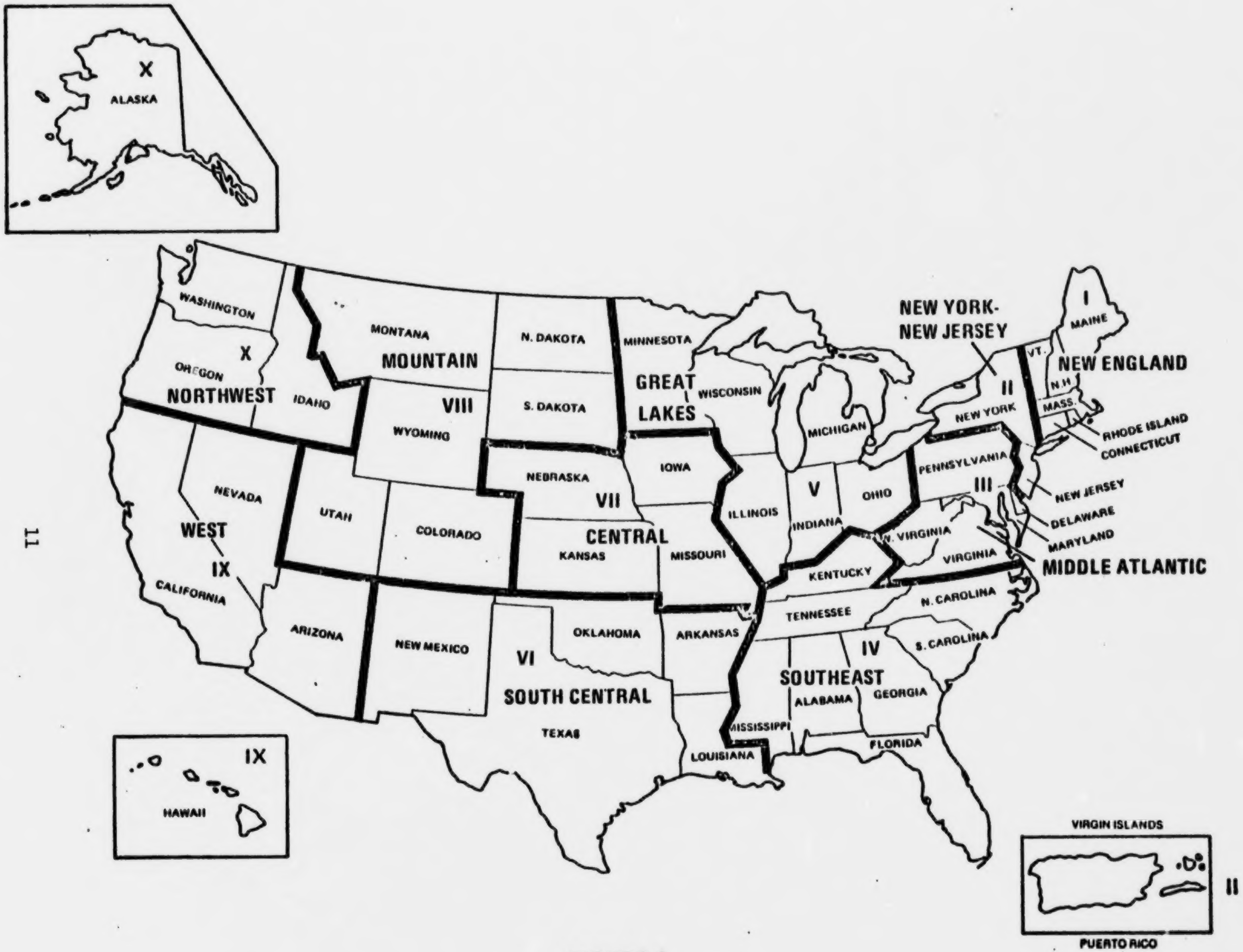
X
ALASKA
WASHINGTON
OREGON
X
NORTHWEST
IDAHO
MONTANA
MOUNTAIN
VIII
WYOMING
N. DAKOTA
S. DAKOTA
MINNESOTA
GREAT
LAKES
WISCONSIN
MICHIGAN
NEW YORK-
NEW JERSEY
II
NEW YORK
I
MAINE
VT.
N.H
MASS.
NEW ENGLAND
RHODE ISLAND
CONNECTICUT
NEVADA
WEST
IX
CALIFORNIA
UTAH
COLORADO
NEBRASKA
VII
CENTRAL
KANSAS
IOWA
MISSOURI
ILLINOIS
V
INDIANA
OHIO
PENNSYLVANIA
III
NEW JERSEY
DELAWARE
MARYLAND
W. VIRGINIA
VIRGINIA
MIDDLE ATLANTIC
KENTUCKY
ARIZONA
NEW MEXICO
OKLAHOMA
VI
SOUTH CENTRAL
TEXAS
ARKANSAS
LOUISIANA
TENNESSEE
N. CAROLINA
S. CAROLINA
IV
SOUTHEAST
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
IX
HAWAII
VIRGIN ISLANDS
II
PUERTO RICO

FIGURE 2
MAP OF THE FEDERAL REGIONS

2.2.1 Particulates

Particulate emissions to the atmosphere are projected in all scenarios to decrease over the forecast period (Table VI). By 1985, point sources are forecast to discharge between 52 and 58 percent of their base year quantities, and between 58 and 66 percent by 1990. The reduction in net emission levels is noteworthy since significant economic growth will be achieved by the major point sources of particulate matter (Table VII).

These reductions are attibutable due to mandated improvements in abatement practices instituted between the base year and 1985. After this period the initial impacts of State Implementation Plans (SIP) and New Source Performance Standards (NSPS) initiatives will have been realized, and further improvements in particulate removal will be minor. After 1985, particulate discharges will increase. However, this increase will be substantially lower than historical (pre-1970) rates of growth due to higher levels of emissions control.

Major scenario differences between forecasts are seen in Table VI and are summarized in Figures 3 and 4. Overall scenario variations are directly related to economic growth assumptions in all but the energy and transportation sectors, with reduced particulate output in the LEG scenario being most significant. In the transportation and energy sectors, significant differences in emission levels are attributable to conservation and energy supply.

Automobile travel accounted for only 3.3 percent of the nation's total output in 1975; however, the contribution to total net particulate levels in 1985 increases to 7.9 percent, 7.8 percent, and 6.6 percent in the NEP, Baseline, and LEG scenarios, respectively. Although this may not appear to be a significant problem nationally, most of the auto transportation emissions will occur in heavily populated urban areas. While the use of catalytic converters, lead free gas, and improved engine design (e.g. positive ventilation crankcase) help to control emission levels, growth in urban population and automobile ownership indicates counteracting increases in automobile emissions. Figures 3 and 4 show significant declines (24.4 percent less than the Baseline scenario) in particulate emissions from auto travel for the LEG case, due to the assumption of reduced personal consumption expenditures.

Scenario assumptions for the industrial coal combustion sector were made to reflect a wide range of potential demands -- from 2.8 to 6.0×10^{15} Btus in 1985 and 3.3 to 8.5×10^{15} Btus in 1990 (Table VII). Therefore it is not surprising that differences in particulate emissions are great among the scenarios. Emissions in the NEP scenario are approximately 40 percent higher than the Baseline

TABLE VI

COMPONENTS OF NET NATIONAL PARTICULATE EMISSIONS
BY SCENARIO

Aggregated Grouping	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Other Structural Materials	5,662	35	3,764	40	67	4,431	41	78
Electric Utilities - Coal	3,803	24	1,271	14	33	1,332	13	35
Industrial Combustion - Coal	1,818	11	507	5	28	510	5	28
Steel	1,171	7	150	2	13	156	2	13
Cement	538	3	109	1	20	131	1	24
Auto Travel	527	3	733	8	139	821	8	156
Other	2,648	17	2,868	31	108	3,253	31	123
Total*	16,165	100	9,402	100	52	10,634	100	66
NATIONAL ENERGY PLAN								
Other Structural Materials	5,662	35	3,477	37	61	4,028	40	71
Electric Utilities - Coal	3,803	24	1,302	14	34	1,304	13	34
Industrial Combustion - Coal	1,818	11	709	8	39	719	7	40
Steel	1,171	7	160	2	14	167	2	14

TABLE VI (Concluded)

Aggregated Grouping	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Cement	538	3	96	1	18	113	1	21
Auto Travel	527	3	743	8	141	764	8	145
Other	2,648	17	2,895	31	109	3,042	30	115
Total*	16,165	100	9,382	100	58	10,138	100	63
LOW ECONOMIC GROWTH								
Other Structural Materials	5,662	35	3,598	43	64	4,265	45	75
Electric Utilities - Coal	3,803	24	1,147	14	30	1,177	12	31
Industrial Combustion - Coal	1,818	11	350	4	19	361	4	20
Steel	1,171	7	138	2	12	147	2	13
Cement	538	3	106	1	20	128	1	24
Auto Travel	527	3	554	7	105	581	6	110
Other	2,648	17	2,526	30	95	2,819	30	106
Total*	16,165	100	8,418	100	52	9,476	100	59

*Components may not sum to total due to rounding.

TABLE VII

FORECAST OUTPUT LEVELS FOR MAJOR SOURCES OF PARTICULATE MATTER

	1975		1985			1990	
Source of Particulates	Baseline	National Energy Plan	Baseline	Low Economic Growth	National Energy Plan	Baseline	Low Economic Growth
Other Structural Materials (millions of tons)	1,300	3,580	3,790	3,590	4,140	4,470	4,260
Electric Utilities - Coal (10^{15} Btus)	3.2	5.6	5.4	4.4	6.1	6.4	5.0
Industrial Combustion - Coal (10^{15} Btus)	1.9	6.0	4.2	2.8	8.5	5.1	3.3
Steel Manufacture (million $)	34,350	45,170	44,040	40,040	46,850	46,000	42,150
Cement Manufacture (million $)	9,780	20,870	24,330	23,880	24,870	29,210	28,800

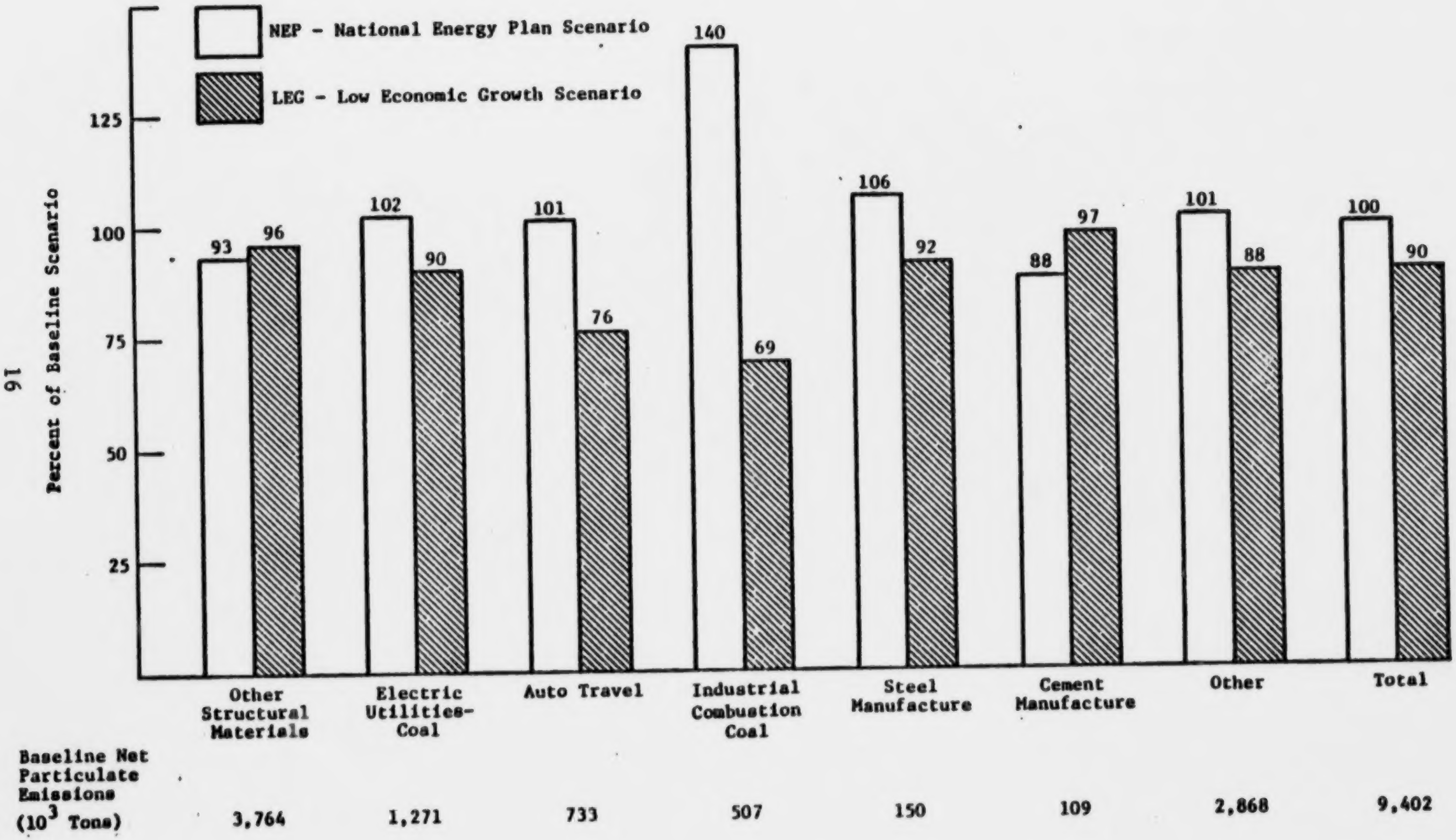

FIGURE 3
1985 NET PARTICULATE EMISSIONS AS PERCENT OF BASELINE SCENARIO

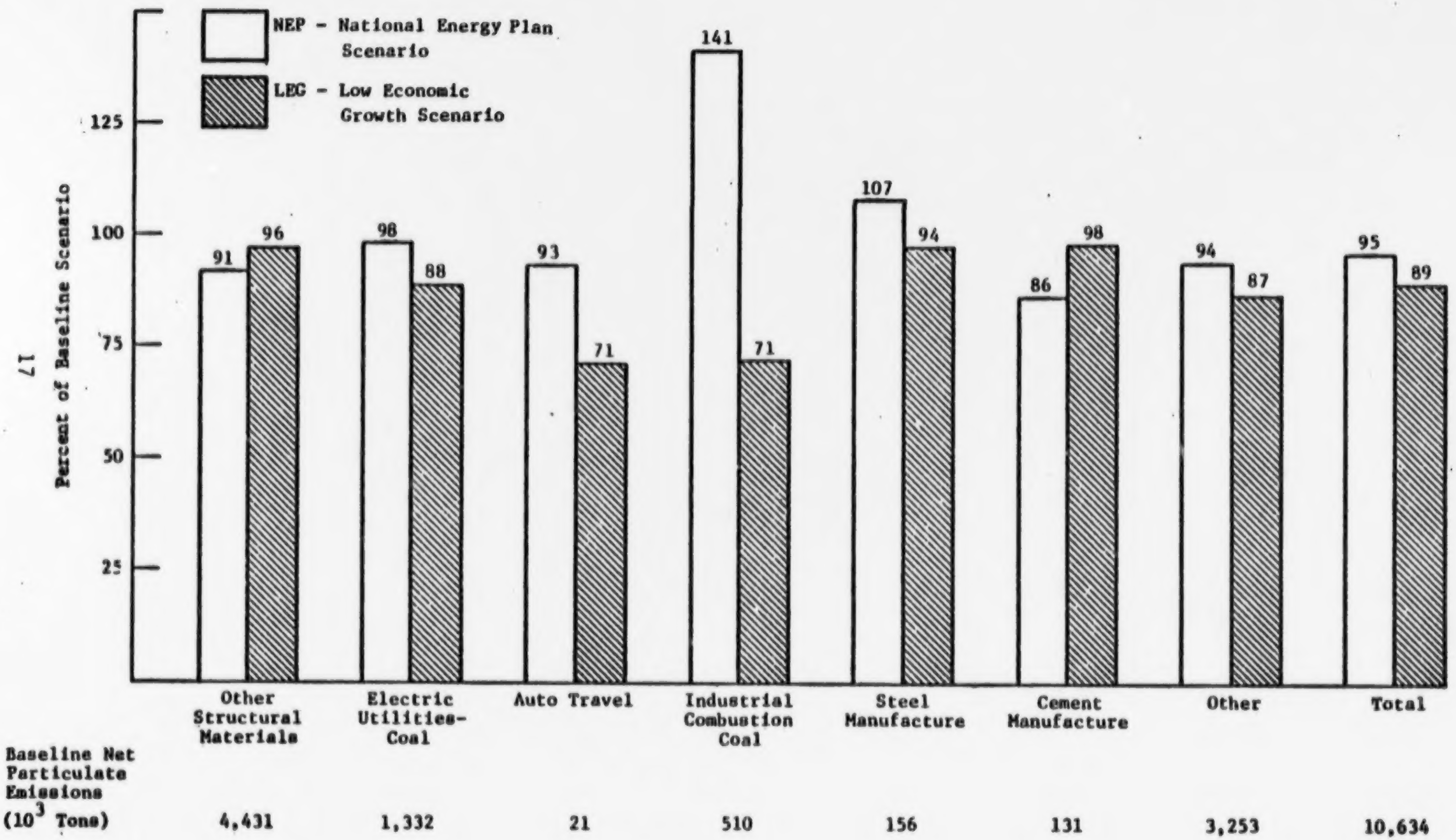

FIGURE 4
1990 NET PARTICULATE EMISSIONS AS PERCENT OF BASELINE SCENARIO

case for this sector, while LEG scenario emissions are 30 percent lower than the Baseline case. In absolute quantities, in 1990, 203,000 tons more particulate matter are emitted to the atmosphere in the NEP than in the Baseline scenario, while 157,000 tons less are discharged in the LEG case.

Differences in particulate emissions from electric utilities among scenarios also are attributable primarily to assumptions concerning coal utilization by utilities. The NEP scenario, with its large coal production levels, projects that utilities will emit 2.4 percent more particulate matter in 1985 than in the Baseline scenario. The LEG scenario forecasts particulate emissions to be 9.8 percent less. For 1990, NEP assumes a greater utilization of nuclear power than the Baseline scenario. Consequently, NEP's 1990 output from coal-fired plants is somewhat lower than in the Baseline scenario. Again, changes in emission levels reflect changes in the activity levels of each scenario. In 1990, the LEG case has 11.6 percent (155,100 tons) less particulates from the utilities sector than the Baseline scenario.

2.2.2 Sulfur Dioxide

Sulfur oxide (SO_x) emissions are expected to decline slightly over the forecast period in all three scenarios (Figure 5). The most significant declines are achieved in the LEG scenario, as sulfur oxide emissions are only 80 percent of the base year value. This large reduction is due mainly to relatively unfavorable economic conditions assumed in the LEG scenario.

Sulfur oxide emissions arise principally from combustion of coal by electric utilities and industry (Table VIII). Copper smelter emissions of SO_x are expected to decrease in the future. In all three scenarios, SO_x emissions decrease by 1985 due to the assumed implementation of SIP, NSPS, and BACT standards. From 1985 to 1990, SO_x emissions increase slightly (an average of 4 percent above 1985 levels) as the assumed growth rates and corresponding development in each of the scenarios cause incremental increases in emissions.

The growth of nuclear utilities and the amount of fuel switching to coal also determine the proportion of SO_x emissions from utilities and industry in each scenario. The NEP scenario assumes that a large number of nuclear power plants come on line over the period to 1990, so that the energy demand met by coal-fired power plants is less by 1990 than that estimated in the Baseline scenario. This has a moderating effect on NEP SO_x emission estimates; by 1990 NEP estimates are slightly lower than Baseline scenario estimates.

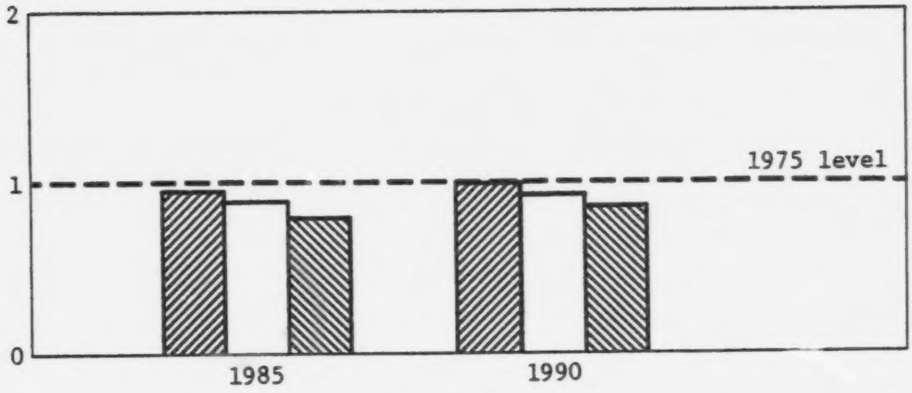

FIGURE 5
FORECASTS OF SULFUR OXIDE EMISSIONS RELATIVE TO 1975 ESTIMATES

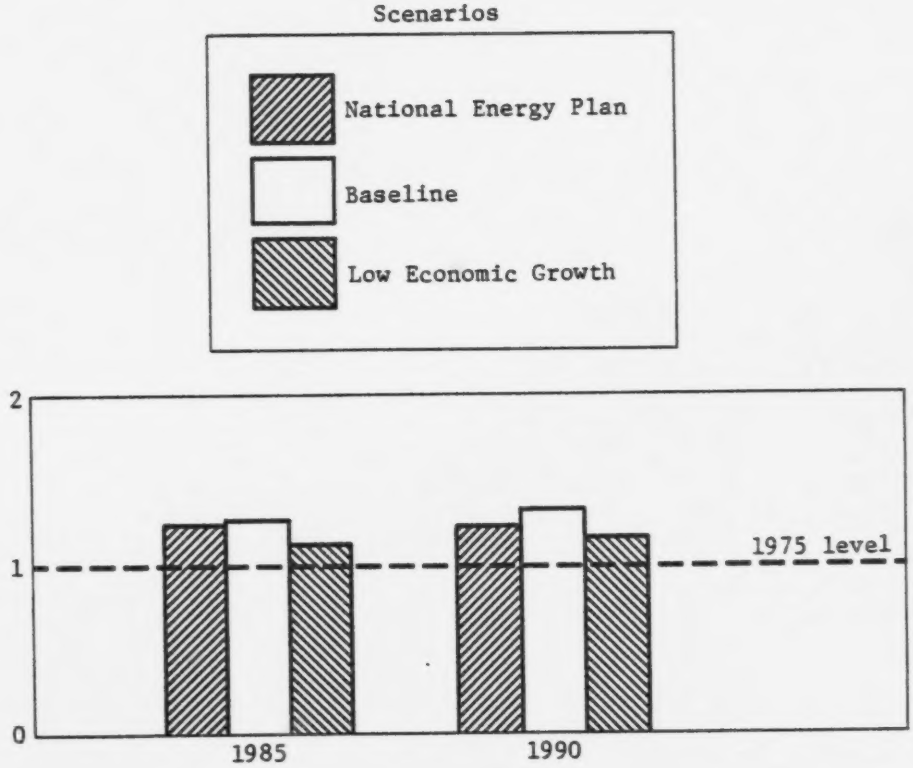

FIGURE 6
FORECASTS OF NITROGEN OXIDE EMISSIONS RELATIVE TO 1975 ESTIMATES

TABLE VIII

COMPONENTS OF NET NATIONAL SO_x EMISSIONS BY SCENARIO

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Electric Utilities - Coal	20,480	63	15,816	57	77	16,395	56	80
Industrial Combustion - Coal	2,675	8	4,337	16	162	4,814	16	180
Copper	2,301	7	623	2	27	657	2	29
Electric Utilities - Oil	1,878	6	1,448	5	77	1,138	4	61
Petroleum Refining & Storage	1,436	4	1,472	5	103	1,604	6	112
Industrial Combustion - Oil	881	3	1,192	4	135	1,344	5	153
Other	3,816	9	2,957	11	78	3,376	12	89
Total*	32,466	100	27,845	100	86	29,327	100	90
NATIONAL ENERGY PLAN								
Electric Utilities - Coal	20,480	63	16,080	56	79	15,974	53	78
Copper	2,675	8	664	2	29	669	2	29
Industrial Combustion - Coal	2,301	7	5,949	21	222	7,482	25	280
Electric Utilities - Oil	1,878	6	854	3	46	747	3	40

TABLE VIII (Concluded)

Sectors	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Petroleum Refining & Storage	1,436	4	1,519	5	106	1,470	5	102
Other	3,816	9	3,780	13	99	3,552	12	93
Total*	32,466	100	28,846	100	95	29,894	100	98
LOW ECONOMIC GROWTH								
Electric Utilities-Old/Coal	20,480	63	14,528	59	71	14,799	58	72
Industrial Combustions-Coal	2,675	8	2,889	12	108	3,167	13	118
Copper	2,301	7	577	2	25	611	2	27
Electric Utilities - Oil	1,878	6	1,499	6	80	1,235	5	66
Petroleum Refining & Storage	1,436	4	1,252	5	87	1,262	5	88
Industrial Combustion - Oil	881	3	903	4	103	1,044	4	119
Other	3,816	9	2,908	12	76	3,302	13	87
Total*	32,466	100	24,556	100	78	25,419	100	81

*Components may not sum due to rounding.

The LEG scenario estimates lower emissions because of assumed lower growth rates and higher levels of oil and gas combustion. This scenario assumes little conversion from oil and gas to burning coal or other energy forms, the lowest percentage of new coal plants, and the highest number of new oil-fired electric utility plants. All of these factors tend to reduce SO_x emissions compared to the Baseline scenario.

Sources of smaller SO_x emissions show fairly stable emission levels in all three scenarios. Reduction of copper smelter SO_x emissions results from emission standard compliance, while reduced electric utility oil combustion emissions in the NEP scenario result from assumptions of decreased oil utilization by the industry.

In conclusion, SO_x emissions in 1985 decrease substantially due primarily to emission controls on electric utility combustion of coal, as well as reduction in copper smelting emissions. Emissions increase slightly from 1985 to 1990 due to increased industrial combustion of coal. Industrial sources of SO_x, especially in urban areas, may become increasingly significant by 1990.

2.2.3 Nitrogen Oxides

All scenarios show growth in net emissions of nitrogen oxide (NO_x) over the forecast period (Figure 6). The projected net growth in emissions reflects existing pollution control regulations which require extensive abatement of NO_x for only one activity--nitric acid manufacture--which accounts for less than one percent of gross loadings in the base year.

Four economic activities account for most NO_x emissions (Table IX): electric utilities, transportation, industrial combustion, and petroleum refining and storage. Together, in 1975 these produced 86.9 percent of all NO_x released to the atmosphere. Assumptions about changing growth rates and fuel mix for these sectors account for much of the differences seen between scenarios.

The average amount of NO_x produced per unit of output by electric utilities is expected to decline sharply by 1985 for the following reasons:

- o the phaseout of oil and natural gas-fired power plants
- o the application of some pollution controls to new coal-fired units which recover about 30 percent of gross emissions
- o the assumed rapid growth of nuclear power.

TABLE IX

COMPONENTS OF NET NATIONAL NO_x EMISSIONS BY SCENARIO

	1975		1985			1990		
Sector	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE								
Electric Utilities - Coal	4,478	22	6,525	27	146	7,359	28	164
Auto Travel	3,682	18	2,754	11	75	2,557	10	70
Truck Travel	2,849	14	4,359	18	153	5,007	19	176
Petroleum Refining & Storage	1,419	7	1,663	7	117	1,802	7	127
Electric Utilities - Oil	1,234	6	1,626	4	83	806	3	65
Electric Utilities - Natural Gas	1,023	5	587	2	57	248	1	24
Industrial Combustion - Coal	758	4	2,754	11	75	2,557	10	70
Industrial Combustion - Oil	625	3	1,108	5	177	1,267	5	203
Other	4,264	21	3,659	15	86	4,671	18	110
Total*	20,332	100	24,435	100	120	26,275	100	129
NATIONAL ENERGY PLAN								
Auto Travel	4,478	22	2,796	11	76	2,379	9	65
Electric Utility - Coal	3,682	18	6,695	27	150	7,048	27	157
Truck Travel	2,849	14	5,434	22	191	5,475	21	192
Petroleum Refining & Storage	1,419	7	1,167	7	82	1,615	6	114
Electric Utilities - Oil	1,234	6	550	2	45	464	2	38

TABLE IX (Concluded)

Sector	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Electric Utilities - Natural Gas	1,023	5	501	2	49	284	1	28
Industrial Combustion - Coal	758	4	2,392	10	316	3,412	13	450
Other	4,264	21	5,632	20	135	5,013	19	121
Total*	20,332	100	25,168	100	120	25,690	100	122
LOW ECONOMIC GROWTH								
Electric Utilities - Old/Coal	4,478	22	5,558	26	124	6,021	27	135
Auto Travel	3,682	18	2,334	11	63	1,963	9	53
Truck Travel	2,849	14	3,325	16	117	3,598	16	126
Petroleum Refining & Storage	1,419	7	1,398	7	99	1,422	6	100
Electric Utilities - Oil	1,234	6	973	5	79	748	3	61
Electric Utilities - Natural Gas	1,023	5	680	3	67	401	2	39
Industrial Combustion - Coal	758	3	1,114	5	147	1,309	6	173
Other	4,264	21	5,331	25	123	6,081	28	141
Total*	20,332	100	21,152	100	106	22,055	100	111

*Components may not sum due to rounding.

The first and last variables are particularly influential in reducing emissions in the NEP scenario. Although NEP reports the fastest growth in electric use by the economy, it also assumes the construction of over a quad (one quadrillion Btus) of additional nuclear generation capacity (4.12 quads rather than 3.07 quads in the Baseline scenario) and the most aggressive policy for phasing the facilities using imported fuels. These changes in utility mix reduce residuals to a point where the Baseline scenario generates 600,000 tons more net NO_x in 1990 than the NEP scenario.

NO_x mobile source emissions are generated by automobiles and trucks. Auto emissions will be greatly reduced due to the application of control requirements set forth in the 1977 Clean Air Act Amendments, as well as anticipated improvements in fleet fuel efficiency. Consequently, in all three scenarios, NO_x from autos declines from 1975 levels, although there are significant differences between scenarios resulting from differences in assumed demands for personal transportation services. In all three scenarios, the changes in the automobile sector are sufficient to cause a reduction in transportation's share of total NO_x generation from 32.1 percent of 1975 residuals to between 20.0 to 30.6 percent of 1990 emissions.

The trucking sector will discharge increasing quantities of NO_x, as abatement requirements on truck exhaust are not as stringent as for automobiles, and fuel economy improvements are more modest. Further, the demand for truck transportation is expected to increase rapidly because of economic growth conditions and substitution of truck for rail transportation. These factors lead to a situation in the NEP and Baseline scenarios in which residuals from trucking in 1990 are almost double 1975 levels, at 5,500,000 tons and 5,000,000 tons, respectively. In the LEG case, modal substitution and overall trucking industry growth are inhibited by the general economic slowdown. Truck emissions in this case are only 25 percent larger than the base year value (3,600,000 tons) resulting in an overall decline in total transportation NO_x.

Emissions from the industrial combustion of fuels increase at a faster rate than any other major source category primarily because of projected rapid increases in coal combustion activity in all the scenarios. Even in the LEG scenario, coal use doubles between 1975 and 1990; at the other extreme, the NEP case reflects a five-fold increase in industrial coal combustion. Coal use increases due to changes in the fuel mixes assumed for new facilities and as a result of fuel switching policies.

A process-specific breakdown of base year (1975) NO_x emissions from the petroleum refining and storage sectors indicates that about 35 percent of these emissions occur during distribution, 35 percent during refining, 20 percent during gathering operations, and 10 percent during other process phases. These shares are not substantially altered during the forecast period.

The implications of the projected increases in NO_x are difficult to assess. In scenarios where mobile source emissions continue to expand, current urban problem areas are likely to persist. The substantial increases in NO_x levels in areas affected by fuel substitution policies may threaten the maintenance of air quality standards in these regions. Conversely, since NO_x emissions, considered separately, are less a universal problem, it is important to view NO_x trends in conjunction with those of photochemical smog hydrocarbons. Since hydrocarbon emissions (see below) decline from 40 to 60 percent over time in the various scenarios, the health and visibility impacts of increased NO_x emissions may be partially or totally mitigated. These questions will be considered in greater detail in the regional analysis.

2.2.4 Hydrocarbons

Total discharges of hydrocarbons (HC) to the atmosphere are forecast to decline in all three scenarios over the analysis period (Figure 7). From 1975 to 1990, emissions are projected to decline at an average annual rate of approximately 2.5 percent in the NEP and Baseline scenarios, and 3.7 percent or more in the LEG scenario, suggesting that economic growth is a more important determinant of HC emissions than fuel mix.

Major sectors responsible for hydrocarbon emissions and their estimated discharges are shown in Table X. Major declines in emission levels are forecast in auto travel, steel production, and municipal sewage incineration, as abatement efficiencies improve. Hydrocarbon emissions from automobiles are reduced between 30 and 50 percent and emissions from steel production and municipal incineration decline significantly.

Major growth in HC emissions is observed in the organic chemicals and petroleum refining and storage sectors despite emissions controls. High growth in output is projected in the organic chemicals industry which accounts for increased emissions levels. Different growth patterns in the scenarios account for the differences in this sector observed in Table X. HC emissions from the petroleum refining and storage sectors are also expected to increase due to higher total consumption levels of oil-based products. The NEP scenario, with its aggressive coal utilization assumptions, shows lower net atmospheric emissions than the Baseline case. Lower emissions in the LEG scenario are attributable to lower oil consumption levels brought about by economic conditions and fuel mix assumptions.

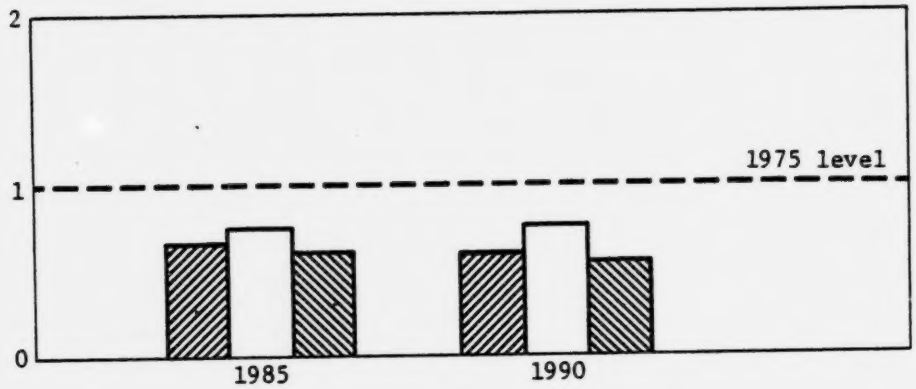

FIGURE 7
FORECASTS OF NET HYDROCARBON EMISSIONS RELATIVE TO 1975 ESTIMATES

Scenarios

▨ National Energy Plan
□ Baseline
▧ Low Economic Growth

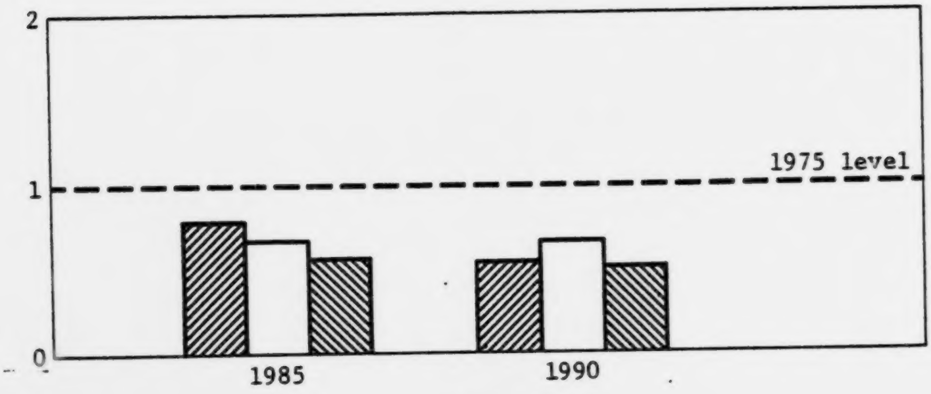

FIGURE 8
FORECASTS OF EMISSIONS OF CARBON MONOXIDE RELATIVE TO 1975 EMISSIONS

TABLE X

COMPONENTS OF NET NATIONAL HYDROCARBONS EMISSIONS

	1975		1985			1990		
Sector	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE								
Auto Travel	4,944	32	2,432	22	49	2,049	19	41
Truck Travel	4,697	30	3,494	31	74	3,394	31	72
Paints	1,573	10	1,642	15	104	1,514	14	96
Petroleum Refining & Storage	1,387	9	1,615	14	116	1,718	16	124
Municipal Sewage/Incineration	512	3	74	1	14	85	1	17
Organic Chemicals	118	1	197	2	167	231	2	195
Other	2,254	15	1,790	16	79	2,022	18	90
Total*	15,484	100	11,244	100	73	11,013	100	71
NATIONAL ENERGY PLAN								
Auto Travel	4,944	32	2,474	20	50	1,907	17	39
Truck Travel	4,697	30	4,352	36	93	3,708	34	79
Paints	1,573	10	1,677	14	107	1,551	14	99
Petroleum Refining & Storage	1,387	9	1,628	13	117	1,539	14	111

TABLE X (Concluded)

Sector	1975 10^3 Tons	1975 Percent of Total	1985 10^3 Tons	1985 Percent of Total	1985 Percent of Base	1990 10^3 Tons	1990 Percent of Total	1990 Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Municipal Sewage/Incineration	512	3	74	1	14	84	1	17
Organic Chemicals	118	1	197	2	167	228	2	193
Other	2,254	15	1,862	15	83	1,969	18	87
Total*	15,484	100	12,263	100	66	10,985	100	59
LOW ECONOMIC GROWTH								
Auto Travel	4,994	32	2,142	23	43	1,564	18	32
Truck Travel	4,697	30	2,614	28	56	2,409	28	51
Paints	1,573	10	1,443	15	92	1,311	15	83
Petroleum Refining & Storage	1,387	9	1,376	15	99	1,408	16	102
Municipal Sewage/Incineration	512	3	63	1	12	70	1	14
Organic Chemicals	118	1	175	2	148	205	2	173
Other	2,254	15	1,586	19	70	1,787	20	79
Total*	15,484	100	9,399	100	61	8,753	100	56

*Components may not sum due to rounding.

Hydrocarbon emissions resulting from activity in service industries and coal-fired electric utilities increase in all scenarios. Their contribution, however, remains negligible throughout the forecast period.

2.2.5 Carbon Monoxide

Figure 8 shows the impacts of scenario assumptions on net carbon monoxide (CO) emissions over the forecast period. Net CO emissions are expected to decline substantially from 1975 to 1990. The LEG scenario develops CO emission patterns that diverge sharply from the Baseline and NEP scenarios, tending to support the view that economic growth rates play a stronger role than other factors in determining future pollution levels. Net national carbon monoxide emissions by sector are summarized in Table XI.

Major decreases in carbon monoxide emissions occur in auto travel and municipal sewage and incineration. The decrease of emissions in auto travel is large enough to significantly reduce its relative contribution to total net emissions in 1985 and 1990. Conversely, truck transportation becomes the most significant emitter by 1990 because of less stringent emission control standards applied to these vehicles and anticipated growth in trucking activity.

Although emission levels of nontransportation sectors grow, their contribution remains relatively minor. Scenario differences for the steel and pulp and paper industries are the result of economic assumptions. In all scenarios, CO emissions from manufacturing gain in relative importance since absolute discharges from transportation are declining.

2.3 Regional Analysis of Atmospheric Emissions

2.3.1 Particulates

Although national particulate emissions are projected to decline over the forecast period, some areas may continue to have high ambient concentrations. Many western states naturally exhibit high particulate concentrations despite relatively low levels of industrial emissions. Tightening controls on industrial sources such as power plants will not reduce the measured concentration of total suspended particulates (TSP) in such areas.

However, particulate emissions are expected to decline between 1975 and 1990 in most federal regions. With the exception of Regions I (New England) and VI (South Central), where slight increases are projected, emission levels will decrease substantially, especially in Regions III (Middle Atlantic), IV (Southeast), V (Great Lakes), and

TABLE XI

COMPONENTS OF NET NATIONAL CO EMISSIONS

Sector	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE								
Auto Travel	60,784	60	27,850	42	46	22,186	35	37
Truck Travel	30,297	30	26,192	40	87	27,030	43	89
Steel	5,078	5	6,874	10	135	7,399	12	146
Pulp & Paper Manufacturing	1,101	1	1,766	3	160	2,028	3	184
Other	3,997	4	3,605	5	90	4,289	7	107
Total*	101,257	100	66,287	100	66	62,932	100	62
NATIONAL ENERGY PLAN								
Auto Travel	60,784	60	28,328	38	47	20,648	32	34
Truck Travel	30,297	30	32,650	44	108	29,559	46	98
Steel	5,078	5	7,374	10	145	7,789	12	153
Paper & Pulp Manufacturing	1,101	1	1,760	2	160	2,020	3	183
Other	3,997	4	3,745	5	94	4,588	7	115
Total*	101,257	100	73,857	100	73	64,603	100	50

TABLE XI (Concluded)

Sector	1975 10^3 Tons	1975 Percent of Total	1985 10^3 Tons	1985 Percent of Total	1985 Percent of Base	1990 10^3 Tons	1990 Percent of Total	1990 Percent of Base
LOW ECONOMIC GROWTH								
Auto Travel	60,784	60	24,980	44	41	17,286	35	28
Truck Travel	30,297	30	19,927	35	66	19,410	39	64
Steel	5,078	5	6,319	11	125	6,682	14	132
Paper & Pulp Manufacturing	1,101	1	1,561	3	142	1,768	4	161
Other	3,997	4	3,493	6	87	4,514	9	113
Total*	101,257	100	56,279	100	55	49,659	100	48

*Components may not sum due to rounding.

VII (Central), which were among the largest contributors of particulate emissions in 1975 (Figure 9).

Regions II (New York-New Jersey), VIII (Mountain), IX (West), and X (Northwest), which contributed only 15.4 percent of the nation's total in 1975, are expected to decline an average of 23 percent from 1975 to 1985. This reduction will be partially offset by a 12 percent increase from 1985 to 1990. The overall decline in emissions within Region II and IX is due to stricter controls on the manufacture of cement and other structural materials. The projected decline in Regions VIII and X is a result of controls placed on industrial and utility coal combustion. Since emissions from these four regions contribute relatively little to national levels and are expected to decrease from base year levels, further discussion of regional trends focuses on other regions of the country.

Certain activities largely determine regional emission levels. For example, industrial facilities are expected to use increasing amounts of coal because of the relative prices of fuels, government incentives for fuel switching, and increases in overall economic output. Conversely, environmental standards are expected to reduce the level of net particulate emissions. Only in Region VI (South Central), where industrial coal use will increase from 6.1 trillion Btus to 667.4 trillion Btus in 1990, do emissions from industrial coal combustion increase over the forecast period.

Emissions from the combustion of coal by electric utilities are affected by compliance with environmental standards, retirement of old (pre-1976) power plants, fuel switching, and projected regional electricity demand. Based on these factors, emission levels from coal-fired utilities in Regions III, IV, V, VI, and X are expected to decrease from base year levels. In Region IX, where coal conversions called for by the Energy Supply and Environmental Coordination Act (ESECA) are assumed, emissions substantially increase over time (300 percent). Even with this change the sector accounts for only 4 percent of total regional emissions.

Net particulate emissions from the steel industry are expected to decline notably from 1975 to 1985 despite an increase in production levels of over 30 percent. The decline is brought about by more widespread use of electrostatic precipitators on blast furnaces and sinters. This prediction assumes full compliance with State Implementation Plan (SIP) standards by 1985. Consequently, increases in steel output after 1985 result in increased emissions. A similar trend occurs in the cement manufacturing industry where emissions decline substantially from 1975 to 1985 despite increasing output levels. Again, full compliance with SIP standards explains this trend. Particulate emissions from this industry in 1990 are slightly higher than in 1985 due to increased output.

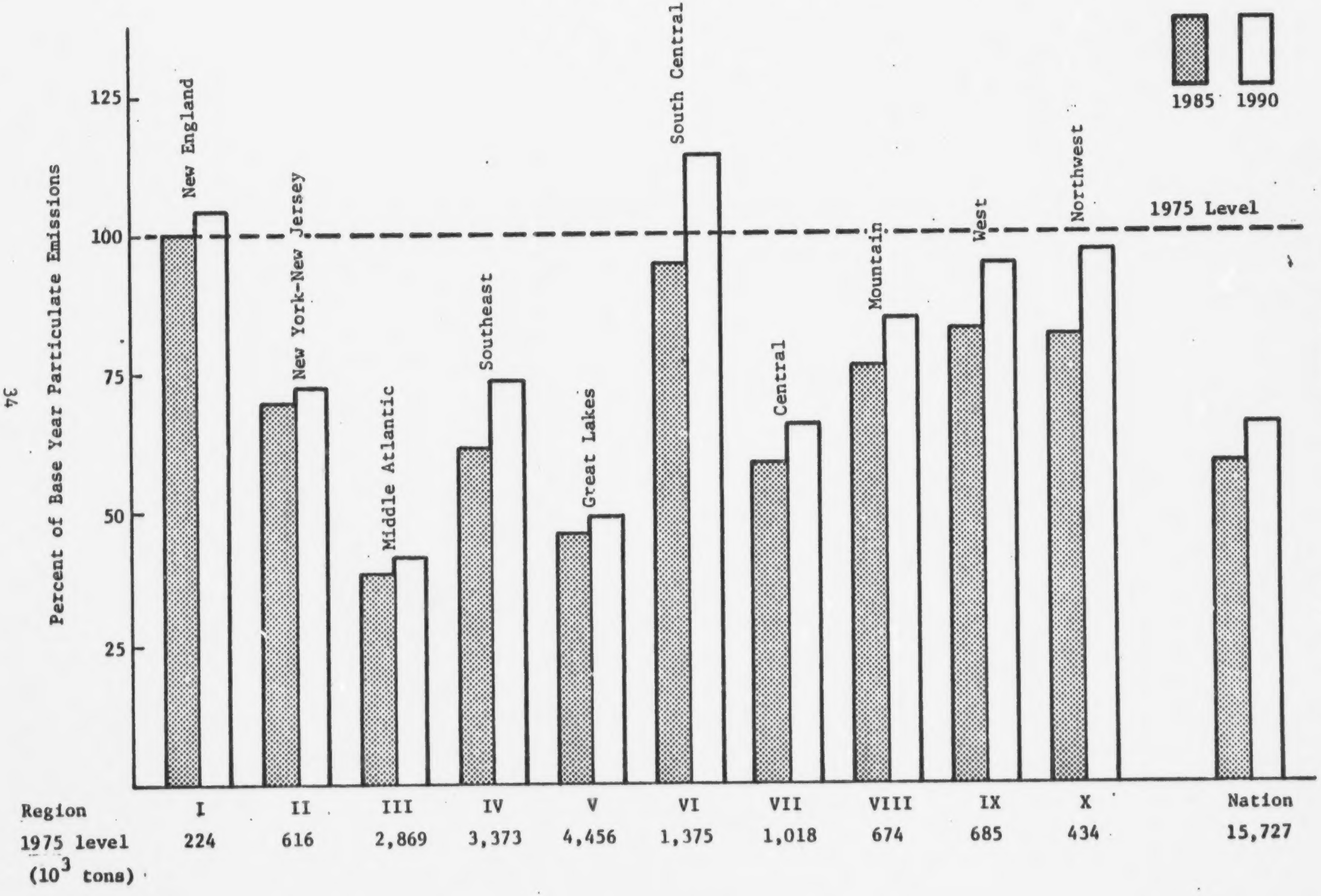

FIGURE 9
TRENDS IN NET ATMOSPHERIC PARTICULATE EMISSIONS BY FEDERAL REGION

The structural materials industry is also subject to SIP standards, as reflected by the lower emission levels in 1985. However, control efficiencies for TSP removal in stone and gravel crushing are lower than the average (about 85 percent as opposed to the 95 to 99 percent achievable in most industries). The factors affecting emission trends in Regions I, III, IV, V, VI, and VII are briefly detailed below. Trends are presented in Table XII.

Region I (New England) - Although Region I was the smallest contributor to the net national particulate level in 1975, 40 percent of the counties in this region were in violation of both primary and secondary standards. It is unlikely that this condition will improve markedly if the current ESECA recommendations concerning fuel switching are followed. Plants switching from oil and gas to coal are classified under the SIP standard. Because of the difficulty and expense associated with retrofitting air pollution equipment on existing plants, this standard is less stringent than the new plant standard. The ESECA conversions result in a five-fold increase in coal-fired utility emissions between 1975 and 1990.

Region VI (South Central) - By 1990, Region VI is also expected to show a slight increase from its base year emission level. However, unlike Region I, Region VI, with less than 3 percent of its counties in violation of primary and secondary standards in 1975, is not likely to have many direct air quality particulate problems. With current knowledge concerning the formation of sulfates from particulate and SO_2 emissions, it is difficult to assess the impacts of particulate matter on ambient sulfate concentrations.

The two major sources accounting for increased particulate emissions in Region VI are aluminum production and fossil fuel combustion. Emissions from aluminum smelting operations are heavily concentrated in Region VI, which contained 85 percent of the U.S. aluminum production in 1975. Growth in aluminum output in this region will result in an increase of over 200 percent in particulate emissions from this source. Emissions from the structural materials industry follow the national trend, decreasing through 1985, followed by an offsetting growth in industrial output. Controlling emissions produced by coal-fired utilities is expected to reduce base year levels from this source by one-third by 1985. Increases in electric demand from 1985 to 1990 will cause such emissions to rise once again.

Base year levels of compliance for Regions III (Middle Atlantic), IV (South Atlantic), V (Midwest), and VII (Central) are shown in Table XIII. These four regions were the largest contributors to total national particulate emissions in 1975 and contain the greatest number of counties in violation of standards. Particulate emissions

TABLE XII

REGIONAL CHARACTERISTICS OF NET PARTICULATE EMISSIONS

Federal Region	Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
BASELINE								
I New England	224	1.4	225	2.5	100.0	235	2.2	104.6
II New York-New Jersey	616	3.9	426	4.7	69.3	442	4.3	71.9
III Middle Atlantic	2,869	18.2	1,088	11.9	37.9	1,187	11.5	41.4
IV Southeast	3,373	21.5	2,066	22.6	61.3	2,467	23.8	73.1
V Great Lakes	4,456	28.3	2,033	22.2	45.6	2,155	20.8	48.4
VI South Central	1,375	8.7	1,295	14.1	94.2	1,571	15.2	114.3
VII Central	1,018	6.5	592	6.5	58.2	657	6.4	64.6
VIII Mountain	674	4.3	509	5.6	75.6	571	5.5	84.8
IX West	685	4.4	565	6.2	82.5	644	6.2	94.0
X Northwest	434	2.8	351	3.8	81.1	420	4.1	96.8
Total*	15,727	100.0	9,154	100.0	58.2	10,353	100.0	65.8
NATIONAL ENERGY PLAN								
I New England	224	1.4	232	2.5	103.4	227	2.3	104.6
II New York-New Jersey	616	3.9	439	4.8	71.3	426	4.3	69.3
III Middle Atlantic	2,869	18.2	1,077	11.8	37.5	1,121	11.3	39.1
IV Southeast	3,373	21.5	2,016	22.1	59.8	2,317	23.5	68.7
V Great Lakes	4,456	28.3	1,982	21.7	44.5	1,990	20.1	44.7
VI South Central	1,375	8.7	1,363	14.9	99.2	1,605	16.2	116.8
VII Central	1,018	6.5	581	6.4	57.1	619	6.3	60.8
VIII Mountain	674	4.3	526	5.8	78.2	556	5.6	82.5

TABLE XII - (Concluded)

REGIONAL CHARACTERISTICS OF NET PARTICULATE EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN - CONCLUDED									
IX	West	685	4.4	587	6.4	85.7	634	6.4	92.6
X	Northwest	434	2.8	336	3.7	77.6	384	3.9	88.5
	Total*	15,727	100.0	9,143	100.1	58.1	9,882	99.9	62.8
LOW ECONOMIC GROWTH									
I	New England	224	1.4	208	2.5	92.6	214	2.3	95.5
II	New York-New Jersey	616	3.9	439	4.8	71.3	394	4.3	63.9
III	Middle Atlantic	2,869	18.2	974	11.9	34.0	1,059	11.5	16.9
IV	Southeast	3,373	21.5	1,875	22.9	55.6	2,244	24.3	66.5
V	Great Lakes	4,456	28.3	1,841	22.5	41.3	1,949	21.1	43.7
VI	South Central	1,375	8.7	1,130	13.8	82.2	1,374	14.9	100.0
VII	Central	1,018	6.5	541	6.6	53.1	599	6.5	58.8
VIII	Mountain	674	4.3	436	5.3	64.8	466	5.0	69.1
IX	West	685	4.4	491	6.0	71.8	548	6.0	80.0
X	Northwest	434	2.8	318	3.9	73.4	382	4.1	88.2
	Total*	15,727	100.00	8,202	100.1	52.2	9,234	100.0	58.7

*Components may not sum due to rounding.

TABLE XIII

LEVELS OF COMPLIANCE WITH PRIMARY AND SECONDARY AIR QUALITY STANDARDS FOR TOTAL SUSPENDED PARTICULATES IN 1975

		Number of Counties Not in Compliance					
Federal Region		EC-NAPS[a]	PC-NAPS[b]	EC-NASS[c]	PC-NASS[d]	Total Number of Counties	Percent of Noncompliance
I	New England	5	7	3	12	67	40
II	New York-New Jersey	0	5	0	9	83	17
III	Middle Atlantic	6	29	0	2	245	15
IV	Southeast	6	28	4	5	736	6
V	Great Lakes	24	44	19	56	524	27
VI	South Central	2	6	0	4	502	2
VII	Central	3	18	3	5	411	7
VIII	Mountain	8	8	1	5	291	8
IX	West	25	16	15	3	88	67
X	Northwest	0	14	0	6	129	16
National		79	175	45	107	3,076	13

[a] Number of Entire Counties Not Attaining Primary Standard

[b] Number of Partial Counties Not Attaining Primary Standard

[c] Number of Entire Counties Not Attaining Secondary Standard

[d] Number of Partial Counties Not Attaining Secondary Standard

Source:

in these regions are expected to decline an average of 55 percent from 1975 to 1990. This decline is primarily caused by the structural materials industry, with regional emissions declines of 13 percent to 37 percent from base year levels, and emissions from electric utility and industrial combustion of coal declining an average of 69 percent and 77 percent respectively.

Particulate emissions at the state level are shown in Table XIV. Although the unit of measure used by this table, "tons per square mile," cannot be interpreted as ambient air quality, it allows a more meaningful comparison of state values.

In Region I, emission levels in Massachusetts and Connecticut were almost four times the regional average of 3.6 tons per square mile in 1975. Levels of compliance with standards in these two states were also poor.

New Jersey (Region II), Pennsylvania (Region III), and Ohio (Region V), all of which exhibited poor compliance in the base year, each have the highest particulate concentration values in their regions: 19.7, 34.4, and 40.3 tons per square mile, respectively. Tighter controls placed on fossil fuel combustion and structural materials manufacture are expected to reduce emissions in Pennsylvania and Ohio by a third by 1990. Similar improvements in New Jersey are not expected to be as effective in controlling emission levels; the 1990 level is only 6 percent lower than in 1975.

The results of the three scenarios are very similar. Net particulate emissions in the scenarios decline between 42 percent and 48 percent from 1975 to 1985. The largest reduction occurs in the LEG case due to a slower rate of economic expansion. The Baseline and NEP scenarios assume high rates of coal utilization by both the industrial and utility sectors and therefore generate slightly higher emissions.

By 1990, the Baseline scenario has 4 percent more particulates than the NEP and 10 percent more than the LEG scenario. Regions IV, V, and VI account for more than half of the difference between the national estimate from the Baseline scenario and the national estimates in the LEG and NEP cases (see Table XII).

2.3.2 Sulfur Oxides

In the baseline scenario net emissions of sulfur dioxide (SO_x) are projected to decrease by 12 percent from 1975 to 1990. Changes at the federal region level range from a 40 percent decrease in Region IX (West) to a 94 percent increase in Region VI (South Central). Figure 10 shows the trends in regional SO_x emissions for 1985 and 1990.

TABLE XIV

CONCENTRATION OF NET PARTICULATE EMISSIONS BY STATE

Federal Region	State	Tons Per Square Mile 1975	1985	1990
	Connecticut	13	17	17
I New England	Maine	1	1	1
	Massachusetts	12	11	11
	New Hampshire	1	2	2
	Rhode Island	7	8	9
	Vermont	2	1	2
	Average	4	4	4
	New York	10	6	6
II New York-New Jersey	New Jersey	20	18	19
	Average	11	8	8
	Delaware	6	9	10
III Middle Atlantic	Maryland	24	11	12
	Pennsylvania	34	12	13
	Virginia	15	6	8
	West Virginia	20	6	7
	Washington, D.C.*	125	69	78
	Average	24	9	10
	Alabama	16	5	6
IV Southeast	Florida	8	8	10
	Georgia	6	5	6
	Kentucky	12	9	11
	Mississippi	1	1	2
	North Carolina	8	5	6
	South Carolina	6	5	6
	Tennessee	17	6	7
	Average	9	6	7

*Because of Washington, D.C.'s relatively small area, this data should be interpreted with caution.

TABLE XIV (Concluded)

Federal Region		State	Tons Per Square Mile 1975	1985	1990
		Illinois	13	7	8
V	Great Lakes	Indiana	31	13	13
		Michigan	10	7	7
		Minnesota	*	*	*
		Ohio	40	12	13
		Wisconsin	4	3	3
		Average	14	6	7
KEY WESTERN STATES					
		New Mexico	1	<1	1
		Colorado	2	1	2
VIII	Mountain	Montana	<1	<1	<1
		North Dakota	1	1	1
		South Dakota	1	1	1
		Utah	2	1	1
		Wyoming	1	1	1
		Average	1	1	1
		Arizona	1	1	1
IX	West	California	*	*	*
		Nevada	<1	1	1
		Average	2	2	2

*Not available

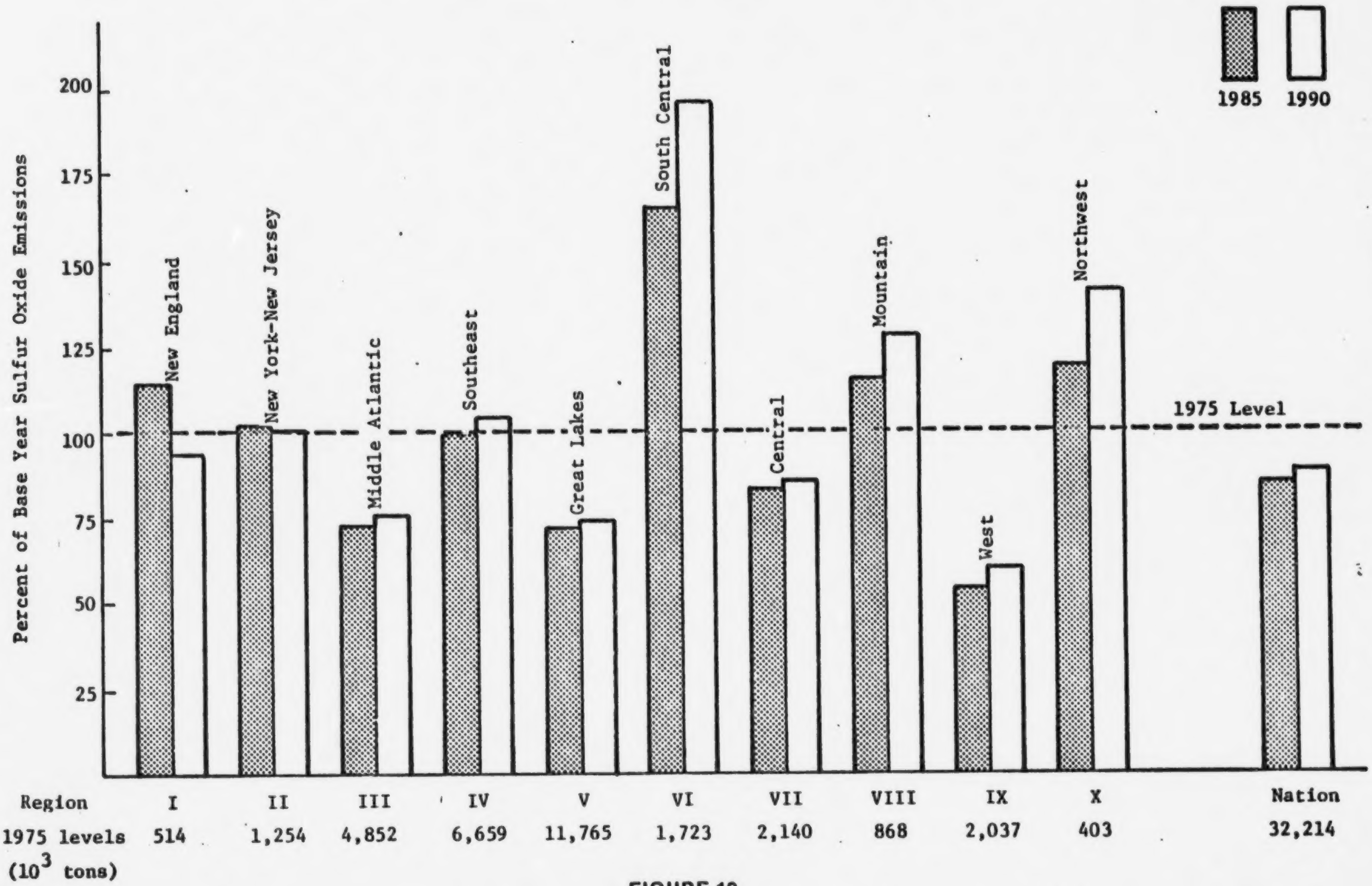

FIGURE 10
TRENDS IN NET ATMOSPHERIC SULFUR OXIDE EMISSIONS BY FEDERAL REGION

The principal sources of SO_x are utility and industrial fuel combustion, copper smelting, and petroleum refining. Attainment of federal pollution control initiatives is expected to reduce emissions from copper smelting and petroleum refining. Increases in combustion related emissions should offset these decreases because scenario conditions favor expanding the utilization of coal in industrial boilers and power plants. The changing mix of sources over time is potentially significant to the relationship between sources and receptors of both SO_x and sulfate compounds.

Regional trend analysis illustrates the changing pattern of SO_x concentrations. These differences are due to large variations in SO_x sources among regions. An excellent example of this is the electric utility combustion of coal. Utility coal combustion is the dominant national source of SO_x, accounting for 63 percent and 56 percent of the total production in 1975 and 1990, respectively. The resultant emissions are not evenly distributed among regions. Regions III (Middle Atlantic), IV (Southeast), V (Great Lakes), and VII (Central) comprised 95 percent of base year discharges; the relative contribution from utility coal combustion ranged from 64 percent to 83 percent in these regions. In the remaining regions, other activities play a more significant role.

Industrial combustion of fossil fuels will increase in national importance as a source of SO_x from 10 percent to 21 percent of total SO_x releases. This increase is most evident in Region VI, where industrial combustion residuals rise from 8 percent of net SO_x in 1975 to 35 percent in 1990. Regions III, V, and VII exhibit similar, but not quite as drastic, increases from 14 percent to 25 percent.

Copper smelting, petroleum refining, and residential and commercial combustion of fuels contribute relatively small amounts of SO_x at the national level, but emissions from these sources are quite large at the regional level. Copper smelters are primarily located in Arizona, Utah, New Mexico, and Montana, and 99 percent of all copper was smelted in the corresponding Regions VI, VIII, or IX during 1978. Because electric utility combustion of coal and oil is low in these regions, copper smelting accounted for one-third, one-fifth, and two-thirds of SO_x emissions respectively. Stringent controls placed on copper smelters are expected to reduce net emissions in Regions VI, VIII, and IX by 57 percent, 72 percent, and 80 percent, respectively, from 1975 to 1990. Petroleum refining is not as centralized an industry as copper smelting; it is only significant in Regions VI (27 percent), IX (14 percent), and X (27 percent). Emissions from residential and commercial combustion of coal and oil are relatively small contributors to the national total; they composed 4.5 percent of the 1975 total. In Regions I (New England) and II

(New York-New Jersey) low emissions from other sources make residential and commercial combustion an important source. Base year SO_x emissions from residential and commercial fuel combustion accounted for 30 percent and 20 percent of the total for Regions I and II, respectively.

The following discussion examines the nation's largest regional contributors of SO_x: Regions III, IV, V, and VI. Region IX is also examined because it shows a decline in emissions four times greater than the national average (see Table XV).

Region III (Middle Atlantic) - The Middle Atlantic region generated 15 percent of the national SO_x emissions in 1975. This share will decrease to 12 percent by 1990, due to the impact of abatement strategies. The major sources of SO_x are coal and oil combustion by electric utilities and industrial facilities, which account for over 90 percent of SO_x emissions in the region. Discharges from these sources decrease by 30 percent from 1975 to 1990, with the greatest improvements occurring in coal-fired power plants.

In 1975, the southwestern section of Pennsylvania was the major problem area in Region III, with one county completely out of compliance, and several adjacent counties partially out of compliance. Increased industrial coal combustion in Region III could worsen the situation. Pennsylvania and West Virginia are receiving an undetermined amount of sulfates transported from neighboring areas in the midwest. As a result, future SO_x emission rates from Region V will influence sulfate formation in this area.

Region IV (Southeast) - The Southeast Region is not expected to show major improvement in SO_x emissions from 1975 to 1990. This is primarily due to expected population growth and inability to reduce net emissions from coal-fired power plants, which accounted for 75 percent of the total in 1975. SO_x emissions from coal-fired utilities are expected to decrease by 20 percent nationally, but only 6 percent in Region IV. Emissions from other sources generally follow trends exhibited at the national level; emissions from all fuel combustion increase and emissions from copper smelting decrease. Significant improvements to the region's air quality are not expected, especially in those counties violating primary and secondary air quality standards during the base year (see Table XVI).

Region V (Great Lakes) - SO_x emissions in the Great Lakes Region are expected to decrease nearly three times as much as the national average decreases despite a 53 percent increase in emissions from industrial fuel combustion. This is due to the stricter levels of control placed on coal-fired electric utilities, the region's largest source of SO_x. The 40 percent drop in utility emissions from 1975 to 1990 shows evidence of this. It is uncertain whether or

TABLE XV

REGIONAL CHARACTERISTICS OF NET SO_x EMISSIONS

Federal Region	Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
BASELINE								
I New England	513,900	1.6	576,000	2.1	112	476,900	1.6	93
II New York-New Jersey	1,253,900	3.9	1,262,000	4.7	101	1,254,800	4.3	100
III Middle Atlantic	4,851,700	15.1	3,478,200	12.5	72	3,676,800	12.7	76
IV Southeast	5,548,500	20.7	6,490,700	24.0	99	6,861,500	23.7	103
V Great Lakes	11,756,000	36.5	8,410,400	30.5	71	8,598,700	29.7	73
VI South Central	1,723,100	5.3	2,816,200	10.2	163	3,343,800	11.5	194
VII Central	2,139,500	6.6	1,785,900	6.5	83	1,845,300	6.4	86
VIII Mountain	868,400	2.7	1,004,300	3.6	116	1,110,500	3.8	128
IX West	2,037,400	6.3	1,126,800	4.1	55	1,227,900	4.3	60
X Northwest	403,000	1.3	480,600	1.7	119	567,900	2.0	141
Total*	32,214,400	100.0	27,531,100	100.0	85	28,327,200	100.0	88

TABLE XV - (Continued)

REGIONAL CHARACTERISTICS OF NET SO_x EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN									
I	New England	513,900	1.6	565,300	2.0	110	467,000	1.6	91
II	New York-New Jersey	1,253,900	3.9	1,186,800	7.2	95	1,132,100	3.8	90
III	Middle Atlantic	4,851,700	15.1	3,488,300	12.2	72	3,464,000	11.7	71
IV	Southeast	5,548,500	20.7	6,525,300	22.9	98	6,599,500	22.3	99
V	Great Lakes	11,756,000	36.5	8,335,600	29.2	71	8,142,700	27.6	69
VI	South Central	1,723,100	5.3	3,701,100	13.0	215	4,811,400	16.3	279
VII	Central	2,139,500	6.6	1,883,000	6.6	88	1,896,100	6.4	89
VIII	Mountain	868,400	2.7	1,114,300	3.9	128	1,166,900	3.9	134
IX	West	2,037,400	6.3	1,251,300	4.4	61	1,329,800	4.5	65
X	Northwest	403,000	1.3	491,100	1.7	172	533,300	1.8	132
	Total*	32,214,400	100.0	28,542,100	100.0	89	29,542,800	100.0	92

TABLE XV - (Concluded)

REGIONAL CHARACTERISTICS OF NET SO_x EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
LOW ECONOMIC GROWTH									
I	New England	513,900	1.6	574,300	2.5	112	493,400	2.0	96
II	New York-New Jersey	1,253,900	3.9	1,157,800	4.9	92	1,120,800	4.5	89
III	Middle Atlantic	4,851,700	15.1	2,991,600	12.8	62	3,150,600	12.6	65
IV	Southeast	5,548,500	20.7	5,975,900	25.5	90	6,155,600	24.5	92
V	Great Lakes	11,756,000	36.5	7,703,000	32.9	65	7,812,000	31.2	66
VI	South Central	1,723,100	5.3	1,130,900	4.8	66	2,248,000	9.0	130
VII	Central	2,139,500	6.6	1,672,400	6.9	76	1,671,800	6.7	78
VIII	Mountain	868,400	2.7	866,200	3.7	100	921,200	3.7	106
IX	West	2,037,400	6.3	960,400	4.1	47	988,800	3.9	49
X	Northwest	403,000	1.3	435,600	1.9	108	512,700	2.0	127
	Total*	32,214,400	100.0	24,423,100	100.0	73	25,074,100	100.1	78

* Components may not sum due to rounding.

TABLE XVI

LEVELS OF COMPLIANCE WITH PRIMARY AND SECONDARY AIR QUALITY STANDARDS FOR SULFUR DIOXIDE IN 1975

		Counties Not in Compliance					
Federal Region		EC-NAPS[a]	PC-NAPS[b]	EC-NASS[c]	PC-NASS[d]	Total Number of Counties	Percent of Noncompliance
I	New England	0	2	0	0	67	3
II	New York-New Jersey	0	1	0	0	83	1
III	Middle Atlantic	1	10	0	0	245	5
IV	Southeast	7	6	0	2	736	2
V	Great Lakes	35	9	0	0	524	8
VI	South Central	1	1	0	1	502	---
VII	Central	0	3	0	0	411	1
VIII	Mountain	2	4	0	0	291	2
IX	West	5	4	0	0	88	10
X	Northwest	0	2	0	1	129	2
Total		51	42	0	4	3,076	3

[a] Number of Entire Counties not Attaining Primary Standard.
[b] Number of Partial Counties not Attaining Primary Standard.
[c] Number of Entire Counties not Attaining Secondary Standard.
[d] Number of Partial Counties not Attaining Secondary Standard.

not this improvement will be sufficient to bring all 44 counties violating primary air quality standards in 1975 into compliance; however, conditions throughout the region are likely to improve.

Region VI (South Central) - Of all the regions, the South Central Region exhibits the largest growth in SO_x emissions, with increases of 63 percent and 94 percent from base year levels in 1985 and 1990, respectively. This may or may not present an air quality problem because base year levels of compliance with primary and secondary air quality standards were met by 499 of 502 counties in the region. The large growth in SO_x emissions is attributable to coal-fired power plants, which will emit 5 times their base year level in 1990 when they switch to western coal, and to industrial coal combustion. Prior to 1976 Region VI used regulated supplies of natural gas for industrial combustion. In the future this region is expected to switch to abundant supplies of low sulfur western coal.

Region IX (West) - As stated earlier, the Western Region exhibits the largest percentage decrease in SO_x emissions from 1975 to 1990, dropping to 60 percent of the base year level in 1990. The major source of SO_x in this region is copper smelting, most of which takes place in Arizona. The 60 percent reduction in SO_x emissions from this source from 1975 to 1990 is due to the implementation of flue gas desulfurization devices. The production of sulfuric acid as a byproduct from the copper smelting process will provide an economic incentive for controlling SO_x emissions.

2.3.3 Nitrogen Oxides

In 1975, only eight counties in the continental United States exceeded the national ambient air quality standard for nitrogen oxides (NO_x). These counties are located in the Los Angeles, San Diego, Denver, and Chicago areas. As shown in Figure 11, NO_x emissions are expected to increase in each region. Unless specific measures are taken, these counties and others will probably violate the 24 hour NO_x standard.

The projected growth in NO_x emissions stems from expected increases in auto and truck travel, and increased reliance on coal as a substitute fuel for oil and gas. Except for automobiles, NO_x emission control is weak. For heavy gasoline and diesel trucks, NO_x emission factors will remain relatively constant from 1972 to 1990. In contrast, by 1980 the NO_x emissions for new model year automobiles are expected to be one-third those of 1972 automobiles.[1]

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[1] Office of Transportation and Land Use Policy, Mobile Source Emission Factors, U.S. EPA, Washington, D.C. March 1978. (EPA-400/9-78-006).

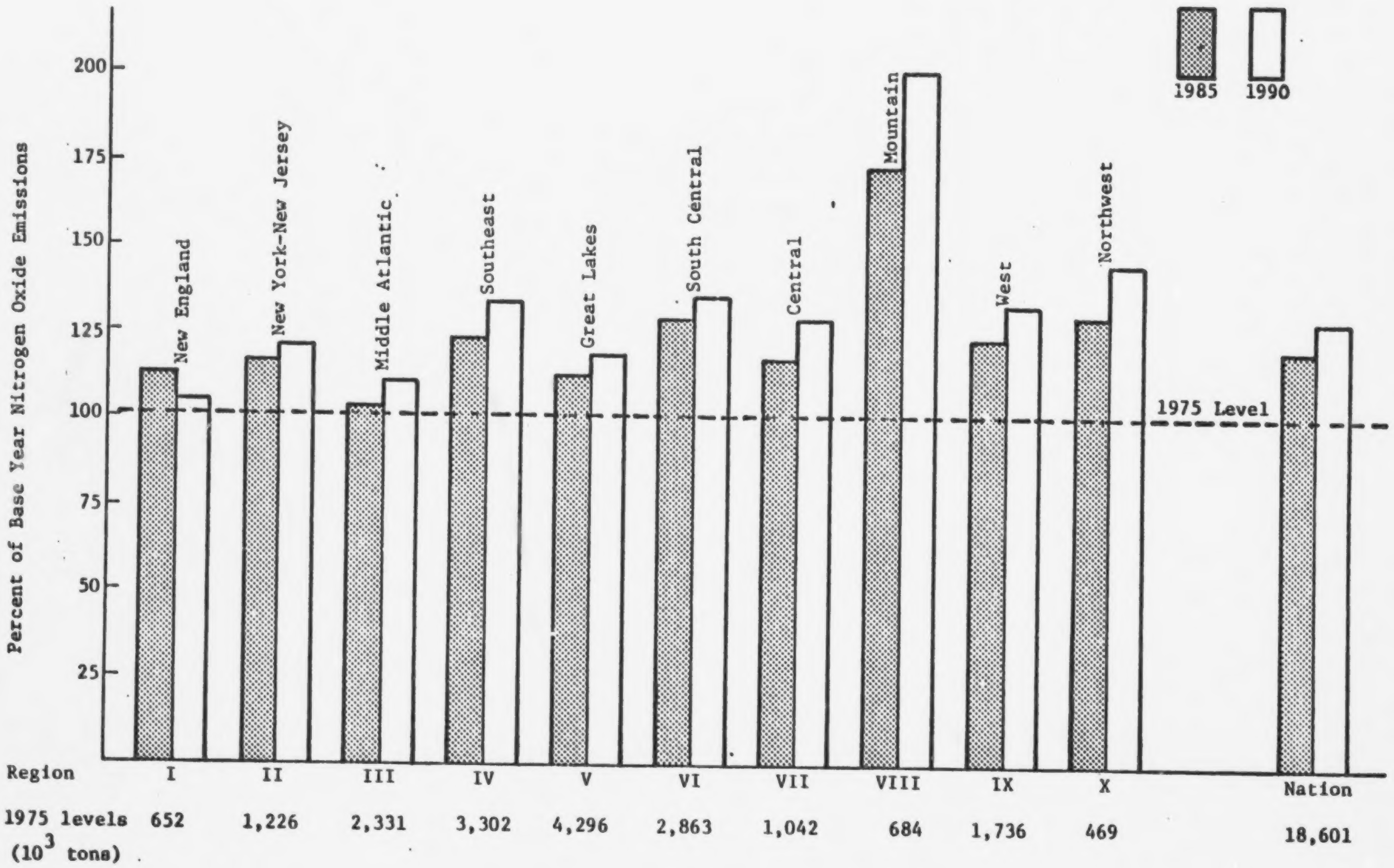

FIGURE 11
TRENDS IN NET ATMOSPHERIC NITROGEN OXIDE EMISSIONS BY FEDERAL REGION

The new source performance standards for coal combustion limit NO_x emissions to 0.7 lbs per 10^6 Btus coal input. This is only 20 percent below the uncontrolled emission rate. More stringent controls could involve NO_x scrubbing, which is more expensive than the boiler inspections which are currently used for NO_x control. Switches to coal combustion from oil and gas combustion are likely to cause higher NO_x emission rates, as coal combustion produces nearly 50 percent more NO_x than gas and oil combustion.

Concern over the potentially dangerous environmental impact of NO_x emissions has prompted Congress, in 1977 amendments to the Clean Air Act of 1970, to call upon EPA to study the desirability of establishing a three hour standard for NO_x concentrations. This, coupled with the forecast NO_x emission increases, could result in many more counties being out of NO_x compliance in the future.

Although the impact of nitrogen oxides on human health is not well known, experts do agree that NO_x has an adverse health effect. Exposure to nitrogen oxides may reduce an individual's resistance to respiratory illnesses.[1] Nitrogen oxides may react with other pollutants, forming mutagenic compounds.[2] The effects of NO_x are difficult to separate from those of other pollutants, and may be dependent on their presence.

Nitrogen oxide emissions are increasing in all ten federal regions (see Table XVII). In 1990, regional nitrogen oxide emissions will increase from 3 percent to over 100 percent above the base year levels. The largest emission increases are projected to occur in Regions IV (South Atlantic), VI (Southwest), and VII (Mountain). Because base year emissions in Region IV were only 2.7 percent of the national total, this region is not discussed.

The large increases in nitrogen oxide emissions in Regions IV and VI are attributed to a relatively large population growth, rapid industrial growth and concomitant increases in energy demand, and a higher reliance on coal in place of oil and gas. As indicated earlier, the emissions of NO_x from coal are approximately one and one-half times those from gas and oil. The large increase in NO_x emissions in Region VIII is attributed primarily to the large growth of utilities. Since the coal supply is abundant, utility growth is

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[1] Benjamin G. Ferris, Jr., MD. "Health Effects of Exposure to Low Levels of Regulated Air Pollutants: A Critical Review," Journal of the Air Pollution Control Association, Volume 28, No. 5, May 1978.

[2] Chemical and Engineering News, March, 27, 1978.

TABLE XVII

REGIONAL CHARACTERISTICS OF NET NO_x EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
BASELINE									
I	New England	651,500	3.5	728,600	3.3	111.8	672,700	2.8	103.3
II	New York-New Jersey	1,226,500	6.6	1,438,000	6.4	117.2	1,475,000	6.2	120.3
III	Middle Atlantic	2,330,900	12.5	2,386,200	10.7	102.4	2,579,300	10.3	105.1
IV	Southeast	3,302,000	17.8	4,046,660	18.1	122.5	4,435,200	18.6	134.3
V	Great Lakes	4,295,800	23.1	4,886,500	21.9	113.8	5,110,100	21.4	119.0
VI	South Central	2,861,200	15.4	3,700,800	16.6	129.3	3,899,800	16.4	136.2
VII	Central	1,042,000	5.6	1,226,400	5.5	117.7	1,341,400	5.6	128.7
VIII	Mountain	683,300	3.7	1,180,100	5.3	172.6	1,367,800	5.7	200.0
IX	West	1,736,400	9.3	2,112,800	9.5	121.7	2,288,600	9.6	131.8
X	Northwest	468,600	2.5	606,700	2.7	129.5	680,900	2.9	637.9
	Total*	18,600,700	100.0	22,321,700	100.0	120.0	23,850,800	100.0	128.2
NATIONAL ENERGY PLAN									
I	New England	651,500	3.5	736,900	3.1	113.1	665,400	2.8	102.1
II	New York-New Jersey	1,226,500	6.6	1,417,200	6.1	115.5	1,382,900	5.8	112.7
III	Middle Atlantic	2,330,900	12.5	2,457,800	10.2	105.4	2,451,200	10.3	105.1
IV	Southeast	3,302,000	17.8	4,115,200	17.7	124.6	4,238,800	17.9	128.3

TABLE XVII - (Concluded)

REGIONAL CHARACTERISTICS OF NET NO_x EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN - CONCLUDED									
V	Great Lakes	4,295,800	23.1	5,013,400	22.9	116.7	4,980,900	21.0	115.9
VI	South Central	2,861,200	15.4	3,917,800	16.9	136.8	4,192,200	17.7	146.4
VII	Central	1,042,000	5.6	1,302,200	5.6	124.9	1,343,000	5.6	128.7
VIII	Mountain	683,300	3.7	1,304,800	5.6	190.9	1,416,900	5.9	207.3
IX	West	1,736,400	9.3	2,274,000	9.8	130.9	2,312,300	9.7	133.3
X	Northwest	468,600	2.5	627,800	2.7	133.9	637,900	2.7	136.1
	Total*	18,600,700	100.0	23,167,500	98.1*	124.5	23,621,400	99.4*	126.9
LOW ECONOMIC GROWTH									
I	New England	651,500	3.5	661,800	3.4	113.1	598,500	3.0	91.8
II	New York-New Jersey	1,226,500	6.6	1,298,400	6.7	105.8	1,303,000	6.5	106.2
III	Middle Atlantic	2,330,900	12.5	2,023,400	10.5	86.8	2,154,900	10.8	92.4
IV	Southeast	3,302,000	17.8	3,488,800	18.1	105.6	3,712,100	18.6	112.4
V	Great Lakes	4,295,800	23.1	4,335,100	22.5	100.9	4,374,900	21.9	101.8
VI	South Central	2,861,200	15.4	3,917,800	16.9	136.8	3,201,200	16.0	111.8
VII	Central	1,042,000	5.6	1,066,900	5.5	102.3	1,135,900	5.7	109.0
VIII	Mountain	683,300	3.7	982,400	5.1	143.7	1,086,600	5.4	159.0
IX	West	1,736,400	9.3	1,762,400	9.1	101.4	1,789,300	8.9	103.0
X	Northwest	468,600	2.5	514,100	2.7	109.7	570,800	2.8	121.8
	Total*	18,600,700	100.0	19,251,000	98.8	103.4	19,927,200	99.6	107.1

*Components may not sum due to rounding.

expected to be substantial throughout the forecast period. Some electricity will be generated for export to the more populous West (IX) and Northwest (X) regions.

2.3.4 Hydrocarbons

Hydrocarbon emissions are a major catalyst in the development of photochemical smog and have a deleterious effect on vegetation. They are a direct cause of eye irritation and can form toxic combinations with other chemical pollutants. They also corrode rubber products and other materials.

The five major national sources of hydrocarbon emissions in 1975 are listed in Table XVIII.

TABLE XVIII

NET HYDROCARBON EMISSIONS IN THE U.S. IN 1975

	Thousands of Tons	Percent
Auto Travel	4,944	32
Truck Travel	4,697	30
Paints	1,573	10
Petroleum Refining & Storage	1,387	9
All Other Sources	2,884	19
Total	15,484	100

These five sources are the major contributors to national hydrocarbon emissions throughout the forecast period. However, by 1990 the widespread use of catalytic converters is expected to reduce the auto travel share of the total to about 20 percent. Truck emissions from 1975 to 1985 will decline at a rate consistent with the national average. Figure 12 illustrates the trends occurring within each region.

The analysis of hydrocarbon emissions examines four polluting sectors. Region VI (South Central) is the only region where another industry is a major emission source; organic chemicals account for 12.3 percent of total HC emissions in this region in 1990. Table XIX shows a breakdown of the major sources within each federal region in 1975 and 1990.

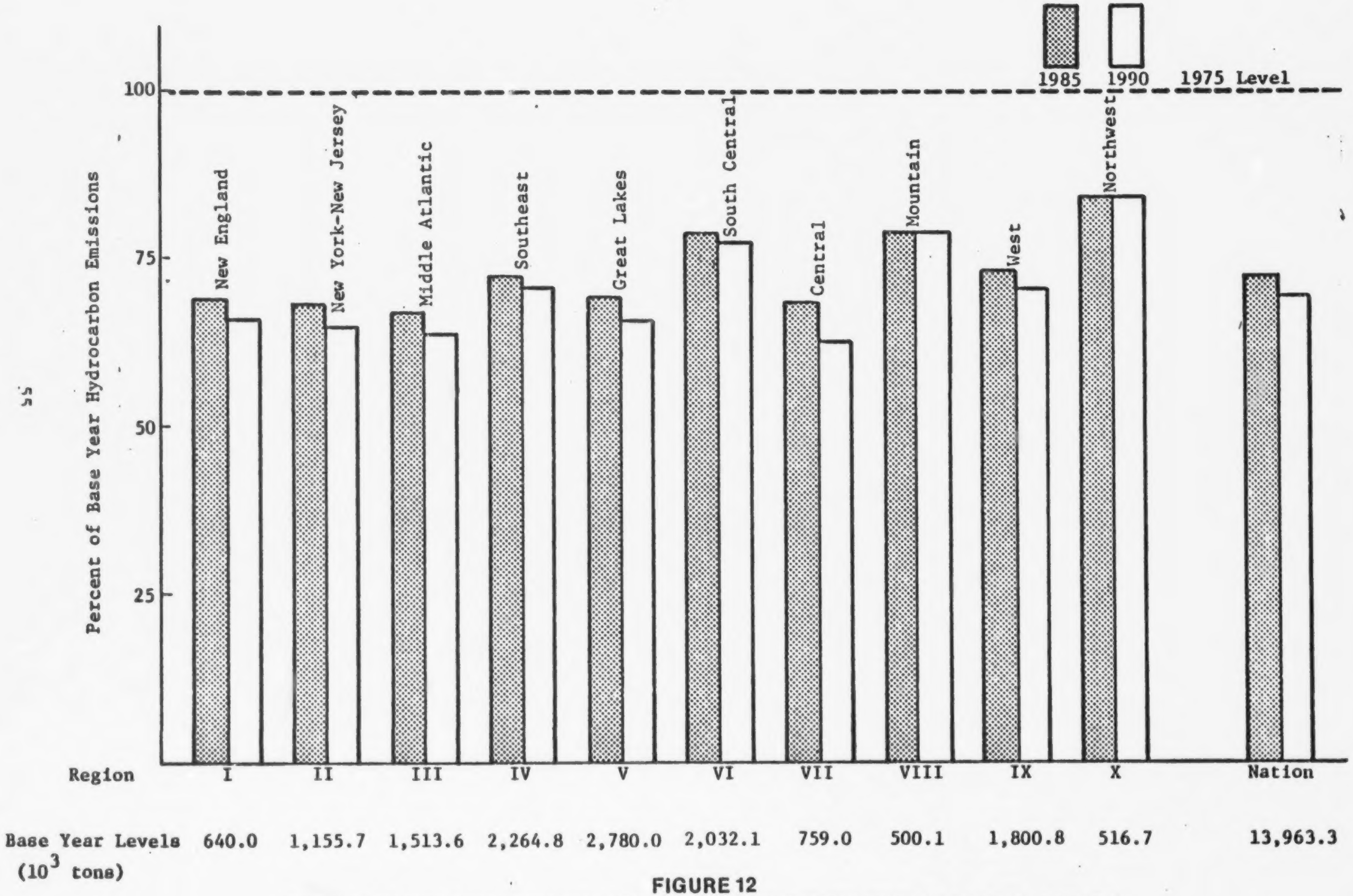

FIGURE 12
TRENDS IN NET ATMOSPHERIC HYDROCARBON EMISSIONS BY FEDERAL REGION

TABLE XIX

SOURCES OF NET HC EMISSIONS BY FEDERAL REGION FOR THE BASELINE SCENARIO

Federal	Region	Year	Percent Distribution				
			Paints	Petroleum Refining	Auto Travel	Truck Travel	Other
I	New England	1975	14.5	0.8	40.9	28.8	15.0
		1990	22.5	1.4	25.8	31.9	18.4
II	New York-New Jersey	1975	15.2	2.7	35.4	27.8	18.9
		1990	18.4	5.3	21.9	31.5	22.8
III	Middle Atlantic	1975	11.0	3.1	35.9	30.3	19.7
		1990	13.8	5.6	24.1	34.4	22.1
IV	Southeast	1975	11.6	0.9	41.2	32.9	13.4
		1990	18.7	2.0	25.0	34.0	20.3
V	Great Lakes	1975	11.6	3.1	36.3	31.5	17.5
		1990	16.2	6.3	22.7	35.1	19.7
VI	South Central	1975	8.5	15.3	28.5	34.2	13.5
		1990	11.1	18.3	14.9	30.7	24.5
VII	Central	1975	10.3	1.9	39.1	35.8	12.9
		1990	14.3	2.5	24.6	40.9	17.7
VIII	Mountain	1975	12.9	6.2	32.1	37.8	11.0
		1990	19.5	13.9*	16.3	33.8	16.5
IX	West	1975	10.2	5.6	32.1	41.6	10.5
		1990	14.1	9.8	18.7	43.1	14.3
X	Northwest	1975	10.3	6.1	33.8	40.0	9.8
		1990	11.6	27.5	16.2	32.8	11.9

*Petroleum refining increased in this region primarily due to the development of shale oil, mostly in Colorado.

Most major industrial centers and urban concentrations are located in Regions I, II, III, V, and IX. About one out of four counties in these regions is in a Standard Metropolitan Statistical Area (SMSA). Since the other regions of the country have a much smaller proportion of counties in SMSA areas, Regions I, II, III, V, and IX are referred to in the text as "industrialized". Standards for hydrocarbon loadings have been established. EPA has made measurements to determine whether an individual county's current discharge level is fully or partially in compliance with these primary air quality standards. Table XX gives a summary of these measurements by federal region.

These tables show the following: 1) current hydrocarbon levels are more of a problem in industrial regions than in nonindustrial regions, and 2) within regions, SMSA related counties, with their higher concentration of economic activity and higher population density, are more likely to violate hydrocarbon standards than non-SMSA counties. A county in an industrial region is seven times as likely to be in violation of primary EPA air quality standards than a county in a nonindustrial region, and a full 87 percent of SMSA counties in industrial regions are in violation, as opposed to 59 percent of nonindustrial SMSAs.

The base year output of net emissions by federal region is shown in Table XXI. The industrial regions contain 942,000 square miles as opposed to the nonindustrial regions' 2,031,300 square miles. The industrial regions have a higher hydrocarbon concentration per square mile than the nonindustrial regions. Net hydrocarbon emissions decrease more in the industrial regions than in the nonindustrial regions (67 percent from base year as opposed to 74 percent). This may be attributable to their lower emission control efficiencies. The gap between industrial and nonindustrial areas will probably close somewhat during the time span of the scenario as industrial concentrations disperse.

The absolute emission levels react fairly uniformly, and the distribution of emission levels between scenarios nowhere changes by an amount greater than one percent in 1990 except for Region VIII. This tends to indicate that the next 15 years are considered to be "near term" future in this context, and that scenario differences will require more time to make their impacts fully felt.

2.3.5 Carbon Monoxide

Regardless of the energy and economic scenario conditions assumed, net carbon monoxide emissions will consistently decline from

TABLE XX

DISTRIBUTION OF COUNTIES IN VIOLATION OF EPA HYDROCARBON GUIDELINES

Federal Region	Total SMSA Counties	SMSA Counties in Violation	Percent of SMSA Counties in Violation	Total Non SMSA Counties	Non SMSA Counties in Violation	Percent of Non SMSA Counties in Violation	Percent of All Counties in Violation
INDUSTRIALIZED							
I	17	17	100	50	48	96	97
II	38	38	100	45	45	100	100
III	57	46	81	188	116	62	66
V	100	82	82	424	76	18	30
IX	22	21	96	66	15	23	41
Subtotal	234	204	87	773	300	39	50
OTHER							
IV	55	38	69	681	26	4	9
VI	56	23	41	446	15	3	8
VII	26	17	65	385	1	<1	4
VIII	14	10	71	277	10	4	7
X	10	7	70	109	2	2	8
Subtotal	161	95	59	1,898	54	3	7
Total	395	299	76	2,671	354	13	21

TABLE XXI

REGIONAL CHARACTERISTICS OF NET HYDROCARBON EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
BASELINE									
I	New England	640,400	4.6	447,700	4.4	69.9	424,800	4.4	59.1
II	New York-New Jersey	1,155,700	8.3	791,400	7.9	68.5	751,100	7.7	65.0
III	Middle Atlantic	1,513,600	10.8	1,016,500	10.1	67.2	967,400	9.9	63.9
IV	Southeast	2,264,800	16.2	1,647,300	16.3	72.7	1,597,800	16.4	70.5
V	Great Lakes	2,780,000	19.9	1,927,200	19.1	69.3	1,838,800	18.9	66.1
VI	South Central	2,032,100	14.6	1,599,200	15.9	78.7	1,581,300	16.3	77.8
VII	Central	759,000	5.4	510,600	5.1	67.3	479,000	4.9	63.1
VIII	Mountain	500,000	3.6	393,400	3.9	78.7	395,000	4.1	79.0
IX	West	1,800,800	12.9	1,312,700	13.0	72.9	1,263,700	13.0	70.2
X	Northwest	516,700	3.7	433,100	4.3	83.8	431,900	4.5	85.0
	Total*	13,963,200	100.0	10,079,200	100.0	72.2	9,730,800	100.0	70.5

TABLE XXI - (Continued)

REGIONAL CHARACTERISTICS OF NET HYDROCARBON EMISSIONS

Federal Region		Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN									
I	New England	640,400	4.6	491,100	4.4	76.6	431,500	4.4	67.4
II	New York-New Jersey	1,155,700	8.3	868,600	7.8	75.2	762,300	7.7	66.0
III	Middle Atlantic	1,513,600	10.8	1,120,500	10.1	56.1	982,700	10.0	64.9
IV	Southeast	2,264,800	16.2	1,816,800	16.3	80.2	1,621,900	16.4	71.6
V	Great Lakes	2,780,000	19.9	2,114,100	19.0	76.0	1,854,400	18.8	66.7
VI	South Central	2,032,100	14.6	1,746,600	15.7	86.0	1,583,700	16.1	77.9
VII	Central	759,000	5.4	568,600	5.1	79.9	488,400	5.0	64.3
VIII	Mountain	500,000	3.6	428,600	3.8	85.7	388,300	3.0	77.6
IX	West	1,800,800	12.9	1,476,800	13.3	82.0	1,296,200	13.2	72.0
X	Northwest	516,700	3.7	503,800	4.5	97.5	439,900	4.5	85.0
	Total*	13,963,200	100.0	11,133,700	100.0	79.7	9,848,400	100.0	70.5

TABLE XXI - (Concluded)

REGIONAL CHARACTERISTICS OF NET HYDROCARBON EMISSIONS

Federal Region	Tons 1975	Percent of Total	Tons 1985	Percent of Total	Percent of Base	Tons 1990	Percent of Total	Percent of Base
LOW ECONOMIC GROWTH								
I New England	640,000	4.6	378,200	4.5	59.1	337,700	4.4	52.7
II New York-New Jersey	1,155,700	8.3	679,400	8.1	58.8	613,200	8.0	53.1
III Middle Atlantic	1,513,600	10.8	848,500	10.1	56.1	763,700	10.0	50.5
IV Southeast	2,264,800	16.2	1,365,200	16.3	60.3	1,250,300	16.3	55.2
V Great Lakes	2,780,000	19.9	1,615,300	19.2	58.1	1,454,000	19.0	52.3
VI South Central	2,032,100	14.6	1,321,800	15.8	65.0	1,259,900	16.4	61.9
VII Central	759,000	5.4	421,600	5.0	55.5	371,200	4.8	48.9
VIII Mountain	500,000	3.6	315,400	3.8	63.1	291,200	3.8	58.2
XI West	1,800,800	12.9	1,071,000	12.8	59.5	971,800	12.7	54.0
X Northwest	516,700	3.7	375,000	4.5	72.6	350,100	4.6	67.8
Total*	13,963,200	100.0	8,391,500	100.0	60.1	7,660,100	100.0	54.9

*Components may not sum due to rounding.

1975 to 1990. During the base year, almost 90 percent of CO emissions were generated by automobile and truck use. In later years, as the impact of mobile source abatement standards are felt, these activities will account for 70 to 80 percent of the total CO. Most of the remainder is generated during steel and pulp and paper production.

Regional CO trends generally mirror the national results. As illustrated in Table XXII and Figure 13, 1990 net emissions in the individual federal regions for the Baseline scenario range from 30 percent to 45 percent lower than 1975 levels, as compared to the national average reduction of 41.2 percent. The regional allocation of CO is strongly correlated with population distribution, which reflects the importance of passenger and freight transportation activity to the estimates. The five largest CO generating regions, III (Middle Atlantic), IV (Southeast), V (Great Lakes), VI (South Central), and IX (West) produced 75 percent of the CO emissions in 1975. These regions contained 70.3 percent of the nation's population. Other regions of importance to this analysis are Regions I (New England) and II (New York-New Jersey). Although their shares of CO emissions are significantly below average considering their population levels, these areas have significant problems of noncompliance with ambient air quality standards due to their high population densities per square mile.

The mix of emission sources contained within each federal region differs in some respects, although mobile sources constitute over 85 percent of emissions in all regions during the base year. Steel production is a substantial CO source in Regions III (12.3 percent) and V (13.2 percent) and is somewhat important in Regions II (New York-New Jersey) and VIII (North Central). Paper production is a significant source only in Regions IV (Southeast) and X (Northwest). These patterns are consistent with the major concentrations of activity in these industries. Since these industrial sources remain almost totally uncontrolled through 1990 while mobile sources are being abated, this difference in source inventories is a particularly important factor explaining interregional differences. The relative importance of auto and trucking activity within each region also differs substantially. In regions east of the Mississippi (I-V), auto emission levels are about 2.5 times as large as the releases resulting from trucking, while in the western half of the U.S. this ratio is only about 1.75. Again, the significance of this difference lies in the relative stringencies of the pollution control standards currently promulgated for the two activities.

From 1975 to 1990, CO levels will decrease due to the impact of federal and local environmental regulations. Auto emissions, in particular, are effectively controlled through the combined effects of

TABLE XXII

TRENDS IN NET CARBON MONOXIDE EMISSIONS
BY FEDERAL REGION
BASELINE SCENARIO

Federal Region		1975		1990		
		Thousands of Tons	Percentage of Total	Thousands of Tons	Percentage of Total	Percentage of Base
I	New England	4,627	5	2,557	4	55
II	New Jersey-New York	7,740	8	4,571	7	59
III	Middle Atlantic	11,588	11	7,779	12	67
V	Great Lakes	21,836	22	15,292	24	70
IX	West	12,484	12	7,397	12	59
IV	Southeast	17,794	18	10,907	17	61
VI	South Central	12,400	12	7,214	12	58
VII	Central	5,629	6	3,030	5	54
VIII	Mountain	3,418	3	1,998	3	59
IX	Northwest	3,741	4	2,187	4	59
	National Total	99,052.8	100.0	58,260.0	100.0	58.8

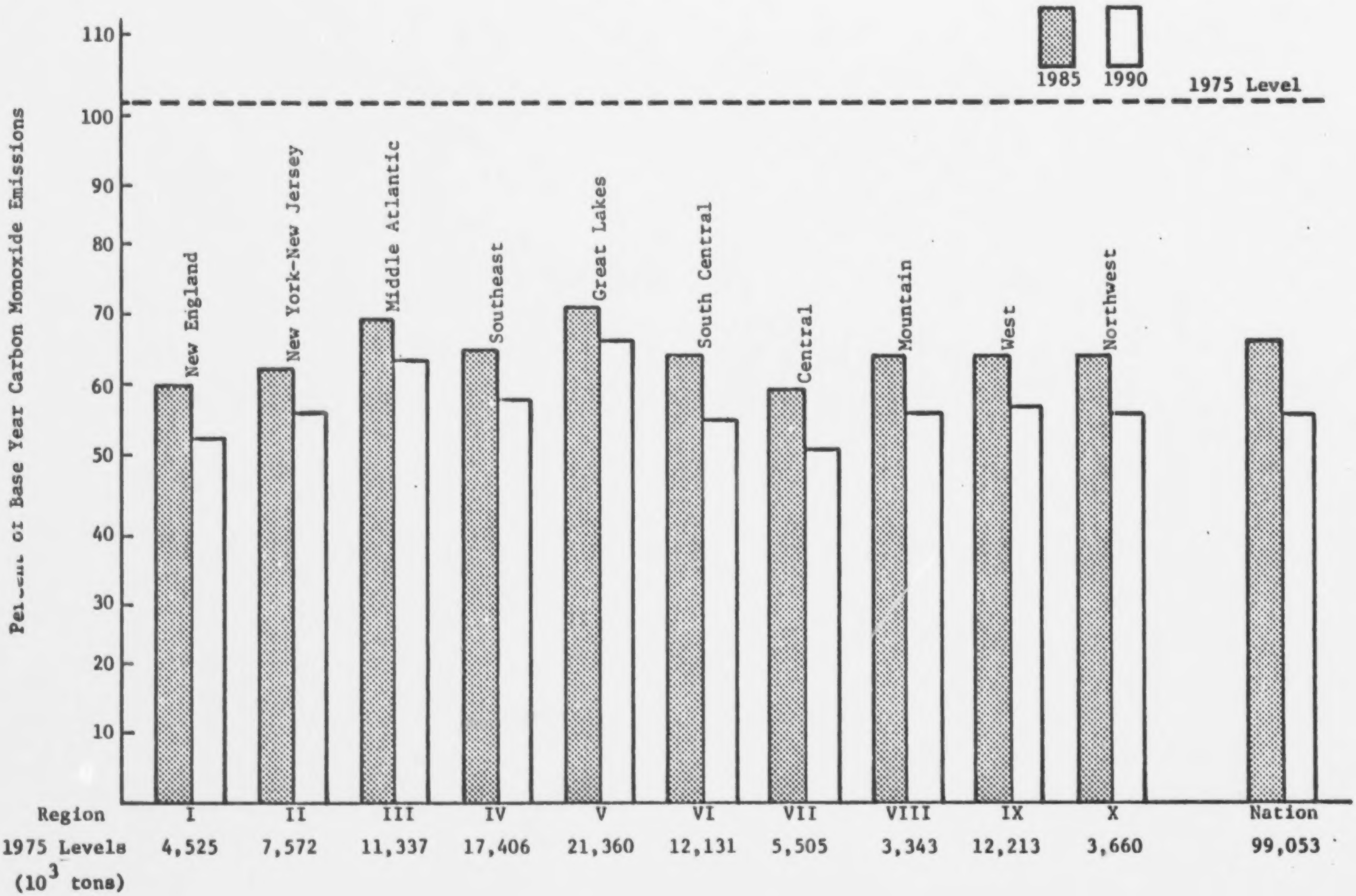

FIGURE 13
TRENDS IN NET ATMOSPHERIC CARBON MONOXIDE EMISSIONS BY FEDERAL REGION

catalytic converter installation and improved gasoline mileage. Emissions from this source decline about 60 to 65 percent although demands for personal transportation continue to increase. The same is true to a lesser extent for trucking, for which emissions at the federal region level will decrease by 12 to 30 percent. These downward trends are slower in areas which contain large scale paper or steelmaking activities (Regions III, IV, and V) because the expansion of these facilities creates new, uncontrolled emission sources.

Table XXIII shows 1990 regional net CO emission estimates for the three EO scenarios. The changes between scenarios are for the most part uniformly distributed among the regions. Where small differences in the scenario impacts do exist, they correlate well with expected shifts in regional population distribution over time.

Table XXIV gives statistics on the current status of regional air quality. Regions I, II, and IX are the only areas that have widespread problems of noncompliance with CO limitations. All three regions contain a large number of major population centers which are indicated by the high percentage of counties belonging to SMSAs. Overall, current violation problems can be almost totally viewed as an urban problem; very few of the 165 nonattainment counties fall outside the boundaries of an SMSA. Since the control of auto related emissions will strike directly at the principal source of urban CO concentrations, improvements are likely to occur.

TABLE XXIII

SCENARIO COMPARISON OF NET REGIONAL CARBON MONOXIDE EMISSIONS IN 1990
(THOUSANDS OF TONS PER YEAR)

Federal Region		Baseline		National Energy Plan			Low Economic Growth		
		10^3 Tons	Percent Total	10^3 Tons	Percent Baseline	Percent Total	Economic Growth	Percent Baseline	Percent Total
I	New England	2,370	4	2,386	101	4	1,844	78	11
II	New Jersey-New York	4,232	7	4,302	102	7	3,345	79	7
III	Middle Atlantic	7,205	12	7,342	102	12	5,831	81	13
V	Great Lakes	14,157	24	14,477	102	24	11,499	81	25
IX	West	6,846	12	7,050	103	12	5,254	77	11
Nonindustrialized:									
IV	Southeast	10,098	17	10,144	100	17	8,023	80	17
VI	South Central	6,677	12	6,814	102	12	5,212	78	11
VII	Central	2,805	5	2,848	102	5	2,172	77	5
VIII	Mountain	1,848	3	1,891	102	3	1,441	78	3
X	Northwest	2,024	4	2,052	101	4	1,593	79	3
	Total	58,260.8	100.0	59,305.1	101.8	100.0	46,213.6	79.3	100.0

TABLE XXIV

COUNTIES IN VIOLATION OF PRIMARY STANDARDS FOR CARBON MONOXIDE IN 1975

Federal Region		Counties in Violation	Total Counties	Percent in Violation
I	New England	14	67	21
II	New York-New Jersey	30	83	36
III	Middle Atlantic	9	245	4
V	Great Lakes	29	524	6
IX	West	32	92	35
IV	Southeast	12	736	2
VI	South Central	6	502	1
VII	Central	7	411	2
VIII	Mountain	15	291	5
X	Northwest	11	129	9
Total		165	3,080	5

3.0 ANALYSIS OF CONVENTIONAL WATER POLLUTANT DISCHARGES

3.1 General

Although regulatory action has reduced industrial discharges into the nation's surface waters and municipal sewage facilities, water pollution remains a serious environmental problem in the U.S. Attaining the nation's primary water quality goal, established by the Federal Water Pollution Control Act Amendments, is important since the population is dependent upon clean water for drinking, recreation, food, agriculture, and industry. Health, employment, and quality of life are thereby related to water quality.[1]

Control of point sources has been mandated by EPA through the application of secondary treatment to municipal sewage and best practicable technology control of water pollution from industrial dischargers. Although deadlines have slipped, particularly with respect to the construction of secondary sewage treatment facilities, control of point-source water pollution is improving steadily. The control of water pollution from nonpoint sources, such as surface runoff from agricultural and urban land, remains a problem. Nonpoint sources may become the most significant contributors of water pollution as control technology for point sources becomes more effective.

This analysis of SEAS water residuals estimates follows the same format as the previous section. SEAS base year estimates and forecasts for conventional water pollutants are identified and discussed. Residuals examined in this section are dissolved solids, suspended solids, oil and grease, biochemical oxygen demand, and chemical oxygen demand. Significant industrial contributors and their discharges projected to 1990 are assessed for their future importance. Important variations between scenarios are identified through the various parameters employed to differentiate the economic and energy assumptions used to construct the three scenarios. Validation of SEAS estimates is attempted in Appendix A.

3.2 National Cross Scenario Comparisons

This section discusses the conventional point source water pollutant discharges estimated by the Baseline, NEP, and Low Economic Growth scenarios. Discharge estimates for these five conventional pollutants are presented for 1975 (base year), 1985, and 1990, for the nation as a whole.

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[1] Council on Environmental Quality, Environmental Quality--1977. Executive Office of the President, U.S. GPO, Washington, D.C., September 1977.

3.2.1 Dissolved Solids

Dissolved solids released to the environment totalled over 21 million tons in 1975 and are expected to increase in all three scenarios to 1990. These totals do not include dissolved solids from municipal treatment. Table XXV shows the growth of residual discharges for the three scenarios and for selected industrial groupings.

Projections show significant sources of dissolved solids throughout the forecast period. Differences between scenarios (Figure 14) are primarily related to assumptions concerning fuel use and industrial growth.

Because of assumed higher output of electricity from coal in 1985, dissolved solids in wastewater discharges in the NEP scenario are 11 percent higher than in the Baseline case. These trends continue through 1990. Due to increased coal utilization in the Baseline case, dissolved solids discharged from coal-fired utilities are only 2 percent greater in the NEP scenario. Higher nuclear output in the NEP scenario further accounts for greater dissolved solids loadings than Baseline estimates in forecast years. Higher utilization of coal for both industrial combustion and electric utilities in the NEP scenario leads to larger quantities of dissolved solids from the coal mining sector, generating 19.4 percent and 11.4 percent more than the Baseline estimates in 1985 and 1990, respectively.

Improved removal efficiencies for dissolved solids discharges are expected to have significant impacts only on the inorganic chemicals industry, for which removal of up to 96 percent of all dissolved solids is estimated by 1985. This will eliminate this sector as a significant contributor of dissolved solids. The organic chemicals industry will remain the major contributor of dissolved solids to the environment due to significant economic growth (estimated at average annual rates of between 4.4 percent and 4.9 percent in the three scenarios), coupled with almost insignificant removal efficiencies.

3.2.2 Suspended Solids

SEAS forecasts of suspended solids discharges show significant declines over the analysis period in all three scenarios (Figure 15). Table XXVI shows that suspended solids discharges will remain a significant problem in only the municipal sewage/incineration sector where compliance schedules to meet secondary treatment requirements have been significantly delayed.[1] The achievement of particularly

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[1] Council on Environmental Quality, Environmental Quality--1977. Executive Office of the President, U.S. GPO, Washington, D.C., December 1977.

TABLE XXV

DISSOLVED SOLIDS DISCHARGED TO 1990
(10^3 TONS PER YEAR)

Sector	1975		1985			1990	
	Baseline	National Energy Plan	Baseline	Low Economic Growth	National Energy Plan	Baseline	Low Economic Growth
Organic Chemicals	8,060	11,510	12,040	10,490	13,180	13,980	12,030
Coal-Fired Utilities	4,340	6,320	5,690	4,820	6,840	6,710	5,410
Coal Mining	2,420	4,300	3,600	3,030	4,690	4,210	3,380
Inorganic Chemicals	1,460	300	310	270	330	350	300
Oil, Natural Gas, Nuclear Utilities	1,880	2,840	2,610	2,770	4,040	2,970	3,160
Other	2,840	2,580	2,310	2,080	2,820	2,700	2,380
Total	21,000	27,850	26,560	23,460	31,900	30,920	26,660

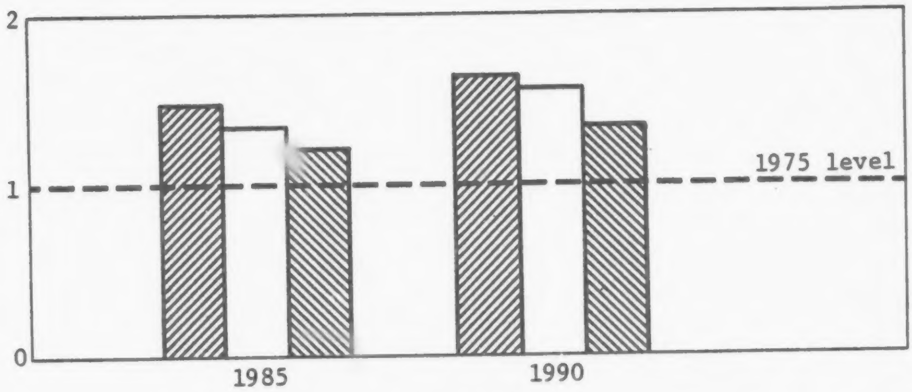


FIGURE 14
FORECASTS OF DISSOLVED SOLIDS DISCHARGES RELATIVE TO 1975 ESTIMATES

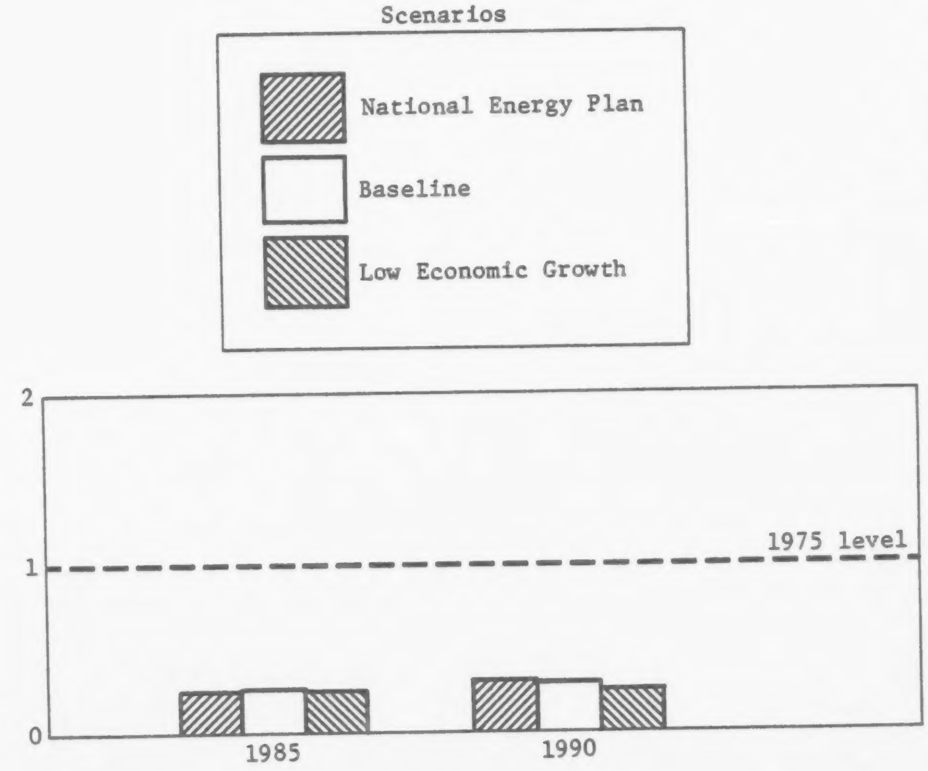


FIGURE 15
FORECASTS OF SUSPENDED SOLIDS DISCHARGES RELATIVE TO 1975 ESTIMATES

TABLE XXVI

MAJOR COMPONENTS OF SUSPENDED SOLIDS DISCHARGES BY SCENARIO

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Municipal Sewage/Incineration	1,474	20	1,202	61	82	1,259	59	85
Aluminum	1,144	16	1	----	<1	1	----	<1
Pulp and Paper	1,105	15	182	9	17	192	9	17
Textiles	993	14	368	19	37	422	20	43
Steel	950	13	25	1	3	19	1	2
Asphalt	536	7	11	1	2	11	1	2
Other	1,093	15	194	10	18	224	11	21
Total*	7,295	100	1,983	100	27	2,128	100	29
NATIONAL ENERGY PLAN								
Municipal Sewage/Incineration	1,474	20	1,202	61	82	1,259	59	85
Aluminum	1,474	16	1	----	<1	1	----	<1
Pulp and Paper	1,105	15	160	8	15	168	8	15
Textiles	993	14	435	22	44	498	23	50

TABLE XXVI (Concluded)

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Steel	950	13	5,463	<1	1	20	1	2
Asphalt	536	7	10,757	1	2	11	1	2
Other	1,093	15	151,819	8	14	169	8	16
Total*	7,295	100	1,966,360	100	27	2,126	100	29
LOW ECONOMIC GROWTH								
Municipal Sewage/Incineration	1,474	20	1,173	64	80	1,210	62	82
Aluminum	1,144	16	1	----	----	1	----	----
Pulp and Paper	1,105	15	160	9	15	166	9	15
Textiles	993	14	309	16	31	356	18	36
Steel	950	13	5	<1	1	14	1	2
Asphalt	536	7	10	1	2	11	1	2
Other	1,093	15	185	10	17	207	11	19
Total*	7,295	100	1,842	100	25	1,965	100	27

*Components may not sum due to rounding.

high removal efficiencies is forecast before 1985 for the aluminum, steel, asphalt, and pulp and paper industries. Over 95 percent of the total residuals produced will be captured. Textiles, although dramatically improving their removal efficiencies, are still expected to discharge significant quantities of suspended solids.

Beyond 1985, some growth in net residuals discharged is expected because of continuing economic growth and expansion, and no further gains in pollutant removal efficiencies. Whether further enforcement measures will reduce absolute levels of suspended solids discharges from municipal sewage treatment plants depends on further Federal funding for secondary treatment works and interceptor sewer systems. Removal efficiency gains are expected to be slight with increased investment in tertiary systems since these systems do not remove significantly more suspended solids than secondary treatment facilities.

Because of restricted net discharges of suspended solids in the waste streams of most significant polluting sectors in 1985, inter-scenario differences are slight. Lower population forecasts in the LEG scenario are expected to affect suspended solids discharges from municipal sewage plants; because the difference in population is less than 6 million by 1985, this parameter is not the only significant determinant of lower discharges. Lower industrial output will also account for lower estimates of suspended solids since a substantial portion of industry uses municipal treatment plants to discharge wastewater.

Discharges of suspended solids are forecast to decline significantly in all three scenarios over the analysis period, due to improved removal efficiencies in most industrial sectors. Municipal treatment plants and textiles will remain significant polluters, with municipal sewage plants contributing approximately 60 percent of all suspended solids to the environment through their effluents. Scenario differences are primarily related to population and industrial growth differences.

3.2.3 Oil and Grease

Discharges of oil and grease forecast in the three scenarios are shown relative to 1975 levels in Figure 16. Only in the Baseline scenario are oil and grease discharges expected to be greater in 1985 than at present. By 1990, however, all scenarios forecast oil and grease discharges to exceed 1975 estimates. The low growth in these discharges between 1975 and 1985 reflects expected industrial compliance with effluent limitations. Effects of economic growth are therefore counteracted by increased removal efficiencies. This is particularly the case in the steel and red meats processing industries, which were major contributors in 1975, but will be virtually

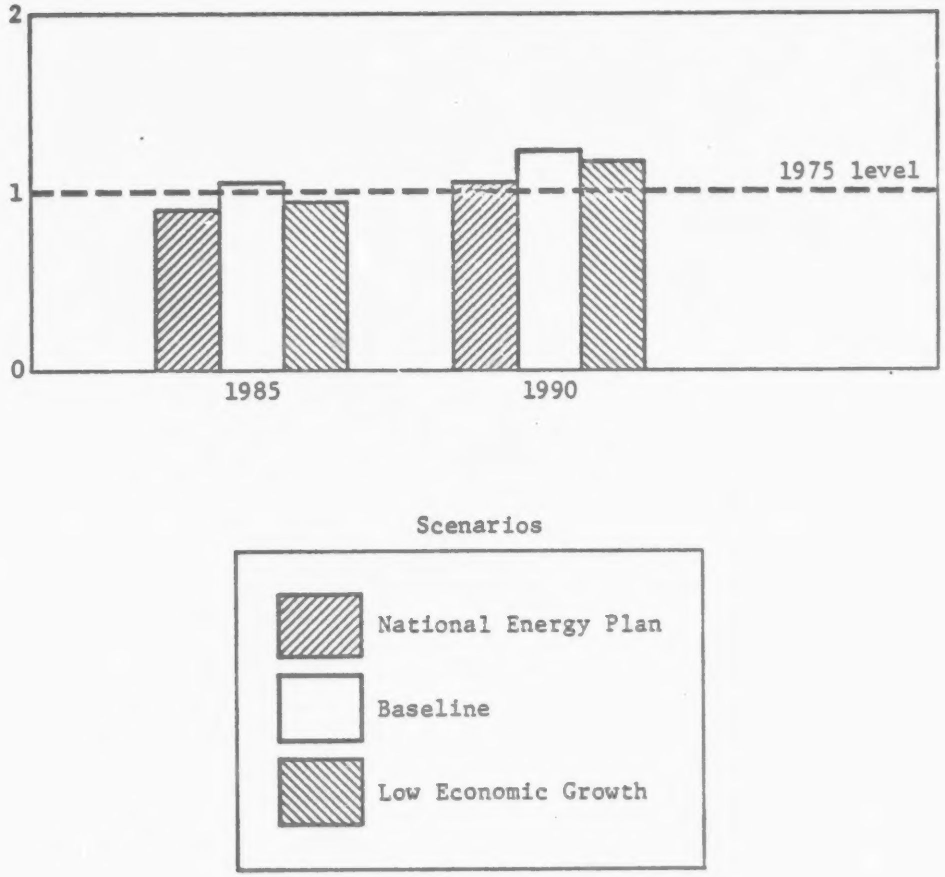


FIGURE 16
FORECASTS OF DISCHARGES OF OIL AND GREASE RELATIVE TO 1975 ESTIMATES

insignificant contributors by 1985. Up to 99.5 percent of all oil and grease residuals discharged in these industries' waste streams are expected to be removed by effluent treatment processes.

Higher relative levels in 1990 reflect the effects of continued industrial growth. No higher removal efficiencies of wastewater treatment devices are expected to be attained from 1985 to 1990. Scenario differences in 1985 and 1990 are attributed almost entirely to the growth variations in the organic chemicals industry (Table XXVII).

Table XXVIII shows average annual growth rates in industrial output and net residuals production forecast for the three scenarios. Relative growth in net residuals discharges remains consistent with growth in output. Absolute growth in the discharges of oil and grease to the environment is less than half that of the output due to higher removal efficiencies of the pollutant from the industrial waste stream. Petroleum refining and storage, though less significant in terms of percentage contribution, pose discharge problems throughout the forecast period. These two industrial sectors are the most significant contributors to oil and grease pollution. Discharges from these sectors are more likely to be toxic to aquatic life than those from other sectors. The extent to which these discharges may be hazardous to environmental and ecological processes should be addressed in future research.

3.2.4 Biochemical Oxygen Demand

Net discharges of BOD are forecast to decline in all three scenarios (Figure 17), due to higher removal rates of organic matter in wastewater treatment facilities. The pulp and paper, fruit and vegetable processing, sugar, and meat products processing industries are expected to achieve greater than 90 percent removal efficiencies by 1985. This will reduce net BOD discharges by the pulp and paper industry from 730,000 tons in 1975 to between 205,000 and 236,000 tons in 1985. By 1990, the pulp and paper industry's relative contribution of BOD to the net wastewater stream is less than half its 1975 value.

The components of net BOD discharges throughout the forecast period for the three scenarios are shown in Table XXIX. In all scenarios, improved removal rates reduce effluent BOD discharge levels to insignificant relative values in meat products processing, organic chemicals, sugar, and fruit and vegetable processing. The meeting of effluent guidelines limitations more than offsets higher gross discharges attributable to the expansion of industrial capacity through 1985 in all the textile industry. Beyond 1985, however, continued economic growth begins to increase net BOD discharges to the environment.

TABLE XXVII

COMPONENTS OF NET NATIONAL OIL AND GREASE DISCHARGES BY SCENARIO

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Organic Chemicals	1,985	80	2,394	90	120	2,934	91	148
Steel	212	9	3	<1	1	3	<1	1
Petroleum Refining & Storage	198	8	231	9	117	240	8	121
Meat Products Processing	65	3	10	<1	16	11	<1	18
Other	33	1	13	1	39	14	<1	42
Total*	2,493	100	2,651	100	106	3,202	100	128
NATIONAL ENERGY PLAN								
Organic Chemicals	1,985	80	1,865	87	94	2,255	89	114
Steel	212	9	3	<1	1	3	<1	1
Petroleum Refining & Storage	198	8	218	10	110	209	8	106
Meat Products Processing	65	3	10	1	15	11	<1	17
Other	33	1	55	3	167	71	3	215
Total*	2,493	100	2,151	100	86	2,548	100	102

TABLE XXVII (Concluded)

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
LOW ECONOMIC GROWTH								
Organic Chemicals	1,985	80	2,181	91	110	2,658	93	134
Steel	212	9	2	<1	1	3	----	1
Petroleum Refining & Storage	198	8	188	8	95	195	7	99
Meat Products Processing	65	3	10	<1	15	11	<1	16
Other	33	1	8	<1	23	8	<1	25
Total*	2,493	100	2,390	100	96	2,874	100	116

*Components may not sum due to rounding.

TABLE XXVIII

COMPARISON OF GROWTH RATES IN TERMS OF OUTPUT AND RESIDUALS PRODUCTION IN THE ORGANIC CHEMICALS INDUSTRY

	1975		1990		Average Annual Growth Rates 1975-1990	
Scenario	Output (millions of $)	Oil and Grease Discharges (10^3 Tons)	Output (millions of $)	Oil and Grease Discharges (10^3 Tons)	Output (Percent)	Oil and Grease Discharges (Percent)
Baseline	27,415	1,985	56,569	2,934	4.9	2.6
National Energy Plan	27,415	1,985	52,406	2,255	4.4	0.9
Low Economic Growth	27,415	1,985	50,647	2,658	4.2	2.0

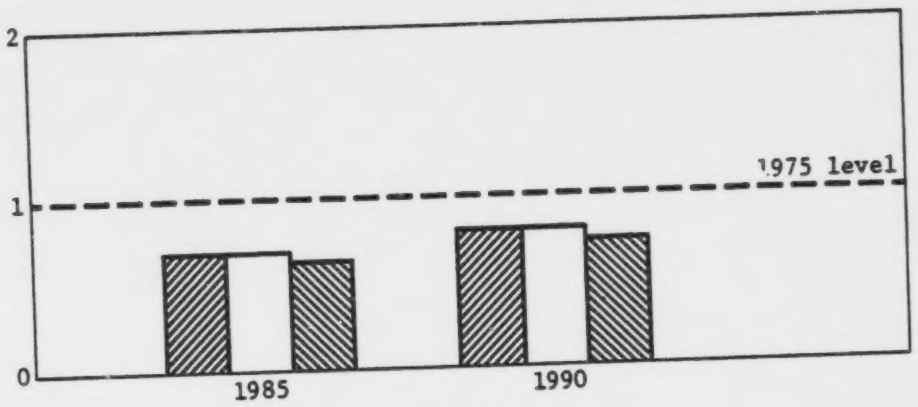
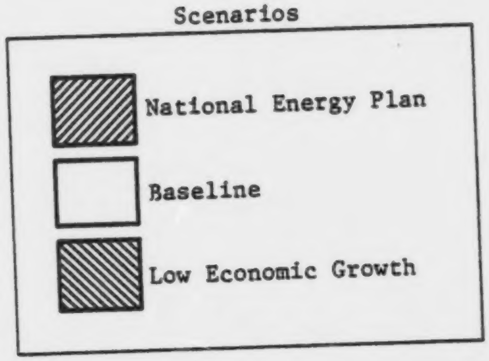


FIGURE 17
FORECAST DISCHARGES OF BOD RELATIVE TO 1975 VALUES


Scenarios
National Energy Plan
Baseline
Low Economic Growth

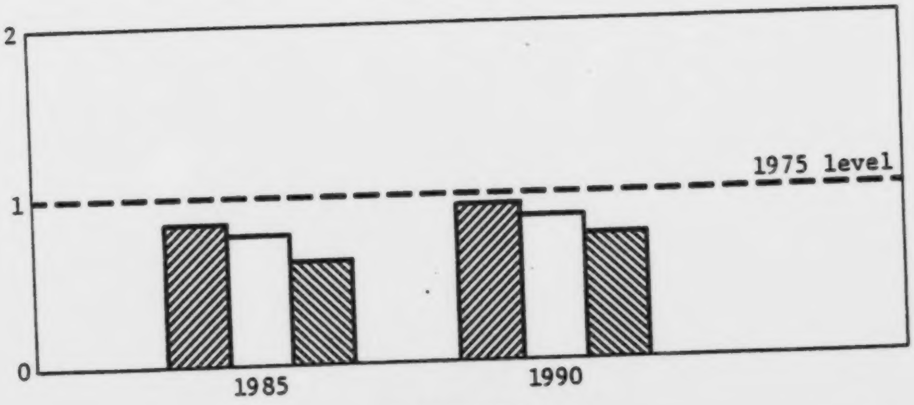


FIGURE 18
FORECASTS OF NET DISCHARGES OF COD RELATIVE TO 1975 ESTIMATES

TABLE XXIX

COMPONENTS OF NET BOD DISCHARGES

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Municipal Sewage/Incineration	1,509	42	1,154	48	77	1,209	46	80
Pulp and Paper	731	20	235	10	32	245	9	34
Textiles	701	19	731	30	104	839	32	120
Meat Products Processing	132	4	12	1	9	12	1	9
Organic Chemicals	101	3	10	<1	10	11	<1	11
Sugar	77	2	<1	---	<1	<1	---	<1
Fruit & Vegetable Processing	69	2	34	1	49	42	2	62
Other	323	9	246	10	76	271	10	84
Total*	3,641	100	2,423	100	67	2,629	100	72
NATIONAL ENERGY PLAN								
Municipal Sewage/Incineration	1,509	42	1,154	47	77	1,210	46	80
Pulp and Paper	731	20	208	9	28	216	8	30
Textiles	701	19	864	36	123	989	37	141
Meat Products Processing	132	4	11	<1	8	12	<1	9

TABLE XXIX (Concluded)

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
NATIONAL ENERGY PLAN (Concluded)								
Organic Chemicals	101	3	9	<1	10	10	<1	10
Sugar	77	2	<1	---	<1	<1	---	<1
Fruit & Vegetable Processing	69	2	35	1	50	43	1	63
Other	323	9	153	6	48	162	6	50
Total*	3,641	100	2,435	100	67	2,642	100	73
LOW ECONOMIC GROWTH								
Municipal Sewage/Incineration	1,509	42	1,126	51	75	1,163	49	77
Pulp and Paper	731	20	206	9	28	211	9	29
Textiles	701	19	613	28	88	707	30	101
Meat Products Processing	132	4	11	1	8	11	1	9
Organic Chemicals	101	3	9	<1	9	11	<1	10
Sugar	77	2	<1	---	<1	<1	---	<1
Fruit & Vegetable Processing	69	2	32	1	46	39	2	57
Other	323	9	213	10	66	231	10	72
Total*	3,641	100	2,209	100	61	2,372	100	65

*Components may not sum due to rounding.

The economies for the scenarios are structurally similar except in the textile industry. Both the Baseline and NEP scenarios forecast high growth rates for this sector in terms of industrial output (Table XXX). Due to capacity expansion over this ten year period in these two scenarios, net discharges of BOD into the waste stream are expected to increase despite higher removal rates of organic materials from the effluent. Low economic growth (LEG scenario) is expected to forestall expansion in the textile sector, resulting in declining net discharges of BOD.

These projections are summarized in Table XXX. Higher economic growth rates lead to net growth in net residuals production in the textile industry. Lower rates of growth, as in the LEG scenario, lead to net declines. Similar growth rates in output are forecast in the textile industry between 1985 and 1990 in all three scenarios. Net discharges of BOD rise accordingly.

Effluent guidelines for the removal of BOD from the waste stream and continued economic growth cause declining (between 27 and 35 percent) total net discharges of BOD by 1990. Adequate removal of BOD from sewage treatment plants is not expected to be achieved by 1990 despite construction of secondary treatment plants, partly because of delays in compliance. Major industrial contributors of BOD are expected to remain the same, although significant improvements are noted in the pulp and paper industry.

3.2.5 Chemical Oxygen Demand

Total net discharges of chemical oxygen demand (COD) are predicted to decline in all three scenarios (Figure 18) over the forecast period, for the industries included in the model. The list of COD producing industries in the model is not complete thus COD totals are not comparable to BOD totals.

The component sources of net COD discharges for the Baseline, NEP, and LEG scenarios are shown in Table XXXI. Declines in net discharges are forecast in all sectors except coal-fired electric utilities. These reductions are attributable to higher removal efficiencies of waste treatment systems. Net COD discharges are expected to increase dramatically in the coal-fired utilities sector because of high growth in coal-fired electricity generation. No removal of COD from wastewater is expected to be practiced in the electric utilities sectors throughout the forecast period, owing to the absence of effluent limitations guidelines for the industry. Declines in oil and gas-fired electricity production in all scenarios, coupled with relatively insignificant contributions of COD from nuclear electric utilities, reduce net COD discharges from the "other electric utilities" sector throughout the analysis period (see Table XXXII).

TABLE XXX

COMPARISON OF RATES OF GROWTH IN OUTPUT AND NET BOD DISCHARGES FOR THE TEXTILES INDUSTRY BY SCENARIOS

	1975		1985[1]		1990[2]	
Scenario	Output (millions of 1971 $)	Net Discharges of BOD (10^3 Tons)	Output (millions of 1971 $)	Net Discharges of BOD (10^3 Tons)	Output (millions of 1971 $)	Net Discharges of BOD (10^3 Tons)
Baseline	32,910	701	54,715 (5.2)	731 (0.4)	61,388 (2.3)	839 (2.8)
NEP	32,910	701	58,921 (6.0)	864 (2.1)	65,764 (2.2)	989 (2.7)
Low Economic Growth	32,910	701	42,878 (2.7)	613 (-1.3)	47,923 (2.2)	707 (2.9)

[1] Average annual growth rates 1975-1985 in parentheses.

[2] Average annual growth rates 1985-1990 in parentheses.

TABLE XXXI

COMPONENTS OF NET COD DISCHARGES

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
BASELINE SCENARIO								
Textiles	7,127	73	4,889	69	69	5,608	70	79
Coal-Fired Electric Utilities	463	4	759	11	164	893	11	193
Organic Chemicals	582	6	233	3	40	272	3	47
Other Electric Utilities	335	3	242	3	72	161	2	48
Other	1,196	12	1,005	14	84	1,085	14	91
Total*	9,703	100	7,128	100	74	8,019	100	83
NATIONAL ENERGY PLAN								
Textiles	7,127	73	5,780	74	81	6,615	75	93
Coal-Fired Electric Utilities	463	5	845	11	183	914	10	198
Organic Chemicals	582	6	218	3	37	251	3	43
Other Electric Utilities	335	3	189	2	56	146	2	44
Other	1,196	12	806	10	67	859	10	72
Total*	9,703	100	7,838	100	81	8,786	100	91

TABLE XXXI (Concluded)

	1975		1985			1990		
	10^3 Tons	Percent of Total	10^3 Tons	Percent of Total	Percent of Base	10^3 Tons	Percent of Total	Percent of Base
LOW ECONOMIC GROWTH								
Textiles	7,127	73	4,099	67	68	4,730	69	66
Coal-Fired Electric Utilities	463	5	641	11	138	720	11	155
Organic Chemicals	582	6	203	3	35	235	3	40
Other Electric Utilities	335	3	276	5	82	210	3	63
Other	1,196	12	858	14	72	933	14	78
Total*	9,703	100	6,077	100	63	6,827	100	70

*Components may not sum due to rounding.

TABLE XXXII

FORECAST OUTPUT OF SIGNIFICANT INDUSTRIAL CONTRIBUTORS OF COD

	1975 Output	1985 Output[1]			1990 Output[2]		
		Baseline	National Energy Plan	Low Economic Growth	Baseline	National Energy Plan	Low Economic Growth
Textiles (millions of 1971 $)	32,910	54,715 (5.2)	60,153 (6.2)	42,878 (2.7)	61,388 (2.3)	65,764 (1.8)	47,923 (2.2)
Chemicals (millions of 1971 $)	27,415	47,802 (6.4)	45,038 (5.1)	43,021 (4.6)	56,569 (3.4)	52,406 (3.1)	50,647 (3.3)
Electric Utilities - Coal (10^{15} Btus)	3.2	5.4 (5.4)	5.6 (5.8)	4.4 (3.2)	6.4 (3.5)	6.1 (1.7)	5.0 (2.6)
Electric Utilities - Oil, Gas, Nuclear (10^{15} Btus)	2.7	3.8 (3.5)	3.9 (3.7)	3.7 (3.2)	4.1 (1.5)	4.3 (2.0)	4.9 (5.8)

[1] Numbers in parentheses are average annual growth rates (1975-1985).

[2] Numbers in parentheses are average annual growth rates (1985-1990).

Scenario comparisons reveal significant variability both with respect to total COD discharges and relative contribution by each industry. Under the LEG scenario, COD discharges are forecast to be 70 percent of their 1975 values, attributable to lower growth rates, particularly in the textile industry and coal-fired electric generating capacity. The NEP scenario forecasts COD discharges to be 90 percent of their current values because of higher economic growth in textiles and greater emphasis on coal-fired electric utilities (Table XXXII). The 1990 total COD value in the Baseline scenario is midway between the NEP and LEG scenario estimates, reflecting more moderate growth rates in textiles and coal-fired electric utilities than the NEP scenario. The organic chemicals industry, although achieving significant growth in all scenarios, reduces its net discharges of COD through improved efficiencies of wastewater treatment (from 41 to 86 percent between 1975 and 1985). Because of these changing growth and wastewater treatment parameters, the relative contributions to COD discharges are distinctly different in 1975 than 1990. Coal-fired electric utilities discharge proportionately more COD than previously, while industrial chemicals discharge proportionately less. Textiles discharge proportionately less COD in the Baseline and LEG scenarios, but marginally more in the NEP case. This latter observation is due primarily to lower discharges from other insignificant sectors (some 20 percent less than the Baseline). Growth in coal-fired utilities relative to other electric utilities also reduces the latter's importance as a contributor to net COD discharges.

3.3 Regional Analysis of Water Residuals

This section summarizes regional trends in the generation and discharge of five conventional water pollutants: biochemical oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), dissolved solids (DS), and oil and grease (OAG).

This analysis highlights regions which contribute significantly to discharges of a given pollutant in the base year relative to the national total discharge, or regions that show a significant change in share from 1975 to 1990.

To make interregional comparisons meaningful, regional shares of economic activity, population, and employment are considered. This provides an indication of the significance of regional water residual discharges. Regional breakdowns of economic and other variables are summarized in Table XXXIII.

Because of the nature of the SEAS regionalization procedure, the macroeconomic assumptions underlying the three scenarios may change the magnitude of the regional shares in a given year without changing

TABLE XXXIII

REGIONAL SHARES OF DEMOGRAPHIC AND ECONOMIC ACTIVITY (PERCENT OF TOTAL)

Region	Land Area	Population	Employed Labor Force	Manufacturing Value Added	Mining Industry Value Added	Value of Farm Production
I	1.8	5.8	6.2	7.2	0.3	1.5
II	1.6	12.5	13.0	14.5	1.0	2.6
III	3.4	11.5	11.6	11.7	9.1	4.5
IV	10.5	15.7	15.1	12.1	6.9	13.8
V	9.1	21.8	22.2	30.3	8.8	20.4
VI	15.5	10.0	9.4	6.4	54.5	13.3
VII	8.0	5.5	5.6	4.7	3.5	20.2
VIII	16.2	2.7	2.6	1.1	6.4	8.5
IX	10.9	11.3	11.2	9.5	8.3	10.9
X	23.0	3.2	3.1	2.5	1.2	4.3

Source: Derived from County and City Data Book, 1977, U.S. Department of Commerce, Social and Economic Statistics Administration, Bureau of the Census.

the direction of the regional trends over the 15 year period. The Baseline and NEP scenarios are quite similar. The Low Economic Growth scenario exhibits lower discharges of the five water pollutants in 1985 and 1990.

Major findings are as follows:

- The concentration of pulp and paper and textiles in Region IV (Southeast) results in high levels of BOD, COD, and TSS in the base year, and noticeable increases by 1990 relative to other regions. These increases are consistent with the recent shift of population and economic activity to the region.

- Region V (Great Lakes) shows a consistent decline in its share of BOD, DS, and OAG.

- In Region VI (South Central), COD, DS, and OAG increase relative to the remainder of the nation. These changes are attributable to the organic chemicals and electric utilities sectors, both of which are high growth sectors located in a region of increasing economic activity.

- Relatively large regional shares of individual water pollutants generally reflect the presence of one or two major industries. The most important industries in this regard are pulp and paper, textiles, coal-fired electric utilities, organic chemicals, and coal mining and preparation activities.

- Patterns of increasing or decreasing regional shares of residuals are generally consistent with regional shifts in economic activity.

3.3.1 Dissolved Solids

Dissolved solids (DS) consist of organic and inorganic molecules and ions that are present in solution in water. These may include sodium, potassium, calcium, magnesium, nitrates, sulfates, and carbonates. They can be both a public health and aesthetic problem in drinking water. DS can also damage industrial or treatment equipment.

The major base year sources of DS included organic chemicals (38.4 percent), electric utilities (29.6 percent), coal mining (11.5 percent), and inorganic chemicals (6.9 percent). Since only the latter source is effectively controlled by abatement regulations, total discharges should increase 47 percent by 1990. Coal mining effluents, in particular, are expected to double over the forecast period due to increased domestic resource exploitation.

The ten federal regions generally follow national trends. The baseline scenario projects loadings in all regions of the country to be higher in 1990 than in 1975; Figure 19 and Table XXXIV show increases ranging from slightly less than 10 percent in Region II to almost 90 percent in Regions VI and X. The regional lists of major regional DS contributors, while generally corresponding to the national data, indicate a disparate mix of pollutant problems. Coal mining, for example, is only an important source of TDS in Regions III, V, and VIII, the major coal production regions. In Region III, residuals from this source constitute 47 percent of total base year discharges and 58 percent of 1990 loadings. Coal mining generates almost half of the TDS of Region VIII by 1990. Effluents from organic chemicals production are more regionally dispersed. Regions I, II, IV, V, and VI are all major centers of processing activity in 1975. The scenario trends indicate major shifts in the industry's locational preferences and/or mix of products. Organic TDS effluents in Regions IV and VI will more than double from 1975 to 1990, while discharges from this industry in Region II will increase by less than 10 percent. This is a major source of interregional disparities in the trend analysis.

Electric power generation is a major emission source in all regions. Coal-fired power plants, however, are not always the principal source of DS. Oil, natural gas, and nuclear power plants also produce substantial quantities. Coal-fired facilities are major sources in Regions III, IV, V, VII, and VIII, while nuclear reactors are most influential in Regions I, II, and X.

Region VI contains the largest share of national TDS discharges in 1990, while Region V was the largest source in the base year. Trends in Regions III, IV, and X are detailed below.

Region V (Great Lakes) - The Great Lakes area is the only one of the five regions discussed above that shows relative decline in its share of net dissolved solids over the 15 year period, from nearly 22 percent in 1975 to about 15 percent in 1990. This regional trend reflects the shift of economic activity and population from this region.

Region III (Middle Atlantic) - The Middle Atlantic states' share of DS is stable over the 15 year period. Sixty-five percent of the net DS expected in 1990 in Region II is attributable to coal preparation and mining, and 19 percent to coal-fired electric utilities. These sectors should grow by at least as much as national trends in both economic activity and discharges of DS.

Regions IV and VI (Southeast and South Central) - Regions IV and VI both increase their share of DS from 1975 to 1990. This is consistent with the shift of economic activity to these regions which

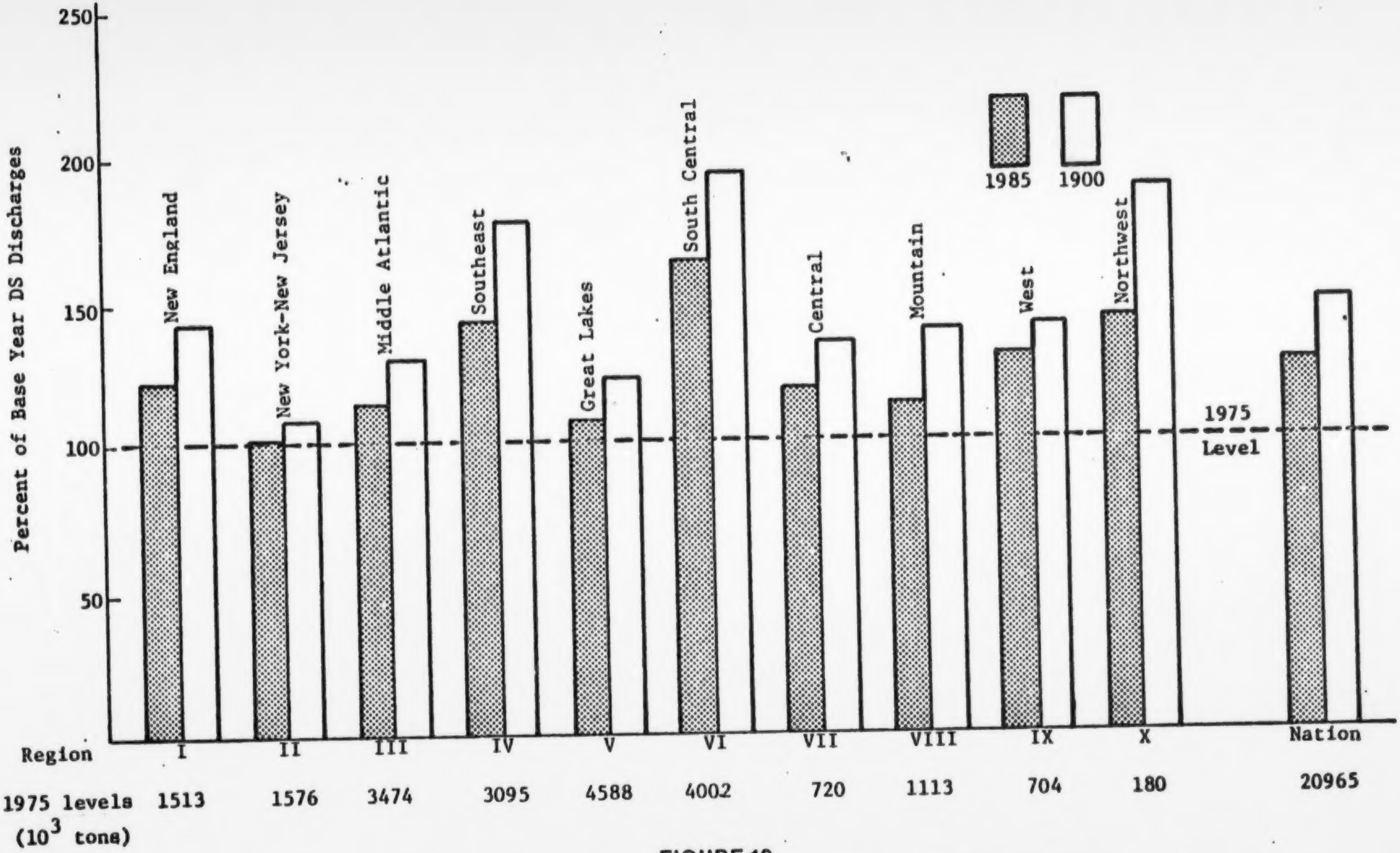


FIGURE 19
TRENDS IN NET DISSOLVED SOLIDS DISCHARGES BY FEDERAL REGION

TABLE XXXIV

NET REGIONAL DISCHARGES OF DISSOLVED SOLIDS
(10^3 tons)

	1975		1985									1990								
Federal Region	Base Year	% Total	Base-line[1]	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base	Base-line	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base
I	1513	7.2	1846	7.0	122.0	1887	6.8	124.7	1636	7.0	108.1	2141	6.9	141.5	2219	7.0	146.7	1854	7.0	122.5
II	1576	7.5	1613	6.1	102.3	1569	5.6	99.6	1394	6.0	88.5	1704	5.5	108.1	1709	5.4	108.4	1439	5.5	91.3
III	3474	16.6	3953	14.9	113.8	4499	16.2	129.5	3483	15.0	100.3	4500	14.6	129.5	4909	15.4	141.3	3830	14.5	110.2
IV	3095	14.8	4371	16.5	141.2	4531	16.3	146.4	3799	16.4	122.7	5452	17.6	176.2	5574	17.5	180.1	4593	17.4	148.4
V	4588	21.8	4958	18.6	108.1	5152	18.5	112.3	4426	19.1	96.5	5627	18.2	122.6	5706	17.8	124.4	4844	18.4	105.6
VI	4002	19.1	6510	24.3	162.7	6536	23.4	163.3	5703	24.6	142.5	7654	24.8	191.3	7546	23.6	188.6	6657	25.2	166.3
VII	720	3.4	864	3.3	119.2	893	3.2	123.2	816	3.5	112.6	972	3.1	134.1	955	3.0	131.7	878	3.3	121.1
VIII	1113	5.3	1267	4.8	113.8	1567	5.6	140.8	957	4.1	86.0	1538	5.0	138.2	1756	5.5	157.8	1192	4.5	107.1
IX	704	3.4	918	3.5	130.4	933	3.4	132.5	797	3.4	113.2	995	3.2	141.3	1076	3.4	152.8	840	3.2	119.3
X	180	0.9	256	1.0	142.2	282	1.0	156.7	218	0.9	121.1	336	1.1	186.7	447	1.4	248.3	267	1.0	148.3
TOTAL	20965	100.0	26556	100.0	126.7	27849	100.0	132.8	23229	100.0	110.8	30919	100.0	147.5	31897	100.0	152.1	26394	100.0	125.9

[1] TAMP NEP

began in the 1960s. Below are the major sectors contributing to net DS discharges in 1990:

Region IV - Coal-Fired Electric Utilities
Chemicals

Region VI - Chemicals

Both of these sectors may be considered high growth sectors given an increasing reliance on coal-fired electric generation and the fundamental importance of chemicals to the economy.

Region X (Northwest) - Man-made discharges of TDS in the Northwest are exceedingly low in the base year. Loadings almost double between 1975 and 1990 due to increased reliance on nuclear power in the region.

3.3.2 Suspended Solids

Suspended solids reduce the efficiency of water supply chlorination, increase the heating of water bodies, reduce dissolved oxygen, and may affect recreational values. Suspended solids are readily controlled, and the 1975 to 1990 trends show a 70 percent decline in national SS discharges.

Major contributors to net base year discharges are municipal sewage, and the pulp and paper, textile, aluminum, asphalt, and steel industries. The last three sources should be over 99 percent controlled by 1985, and will cease to contribute major components of the waste stream. Municipal wastes then become the dominant contributor of TSS, releasing over 59 percent of total discharges.

Regional patterns indicate a varying inventory of TSS sources in the base year. Although municipal sewage treatment is the largest national source, it is the largest regional contributor in Regions I, II, VII, and IX only. Only Region IX generates a significant portion of the national total. Other principal contributors include steel (Regions III and V), textiles (Region IV), bauxite refining (Region VI), paper manufacturing (Region X), and sugar refining (Region VIII). Since some of these sources are almost completely controlled after standards are met, some regions do experience somewhat greater declines in TSS discharges. By 1990, regional source inventories will mirror the national picture with municipal treatment predominant in all areas except Region IV, where textiles will remain the largest source. This anomaly arises from the high concentrations of textile industry in this region, and the lower level of abatement efficiency which is maintained. Changes in total regional effluent levels are fairly uniform, with 1990 output ranging from 18 to 45 percent of base year discharges, as illustrated in Figure 20.

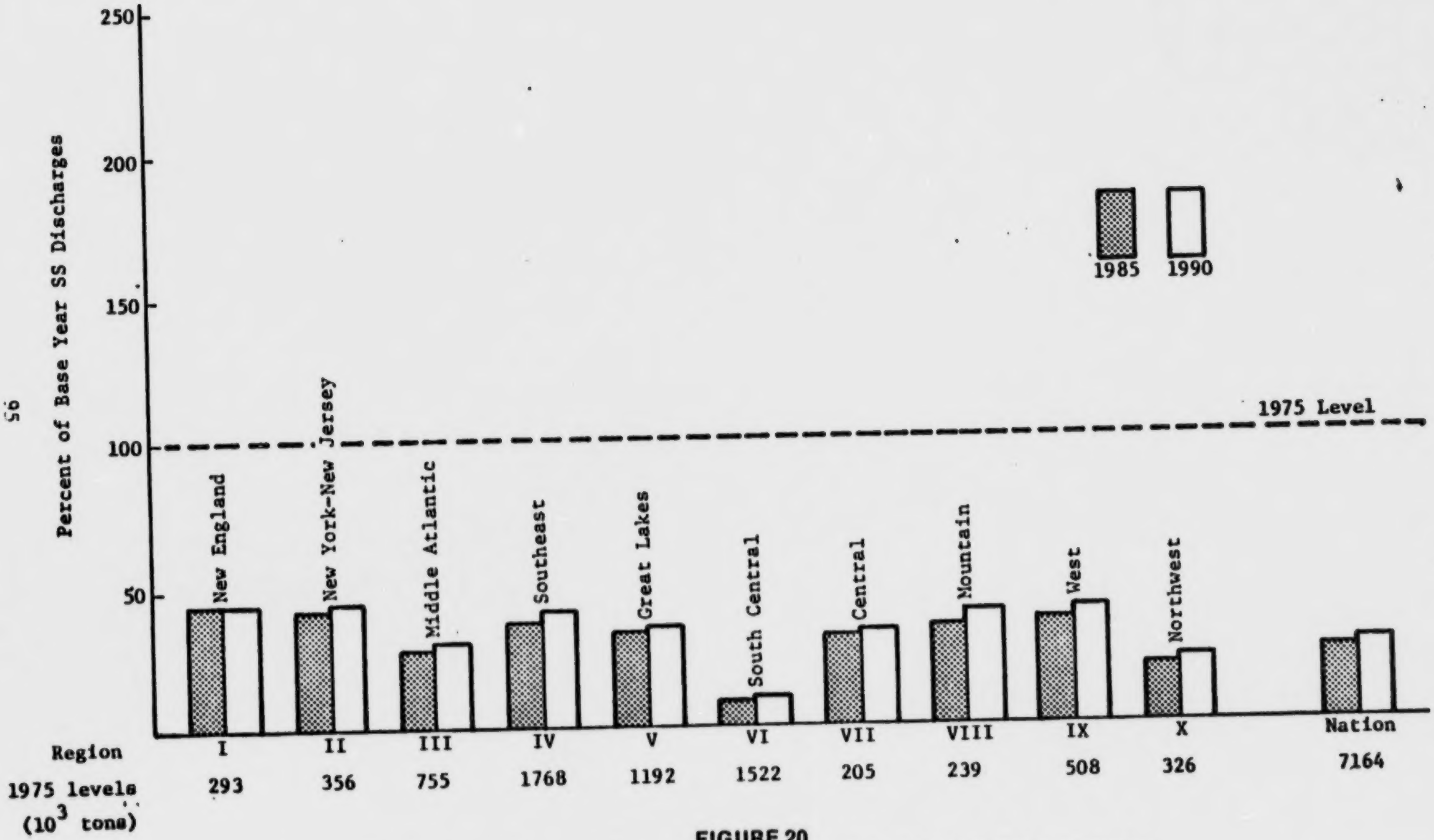


FIGURE 20
TRENDS IN NET SUSPENDED SOLIDS DISCHARGES BY FEDERAL REGION

Regions IV (South), V (Great Lakes), and VI (Southwest) were the largest sources of TSS in 1975. These regions are of particular interest because of their widely differing trends in emissions. They are discussed briefly below and in Table XXXV.

Region IV (Southeast) - The South contributes the largest share of suspended solids in all years. This could not be anticipated from the region's share of national employment or manufacturing value added. The regional share increases significantly by 1990 to approximately 30 percent of national TSS. This increasing share appears to be caused by the major concentrations of textile and pulp and paper production in the area, as well as population migration to the region, which may presage increased discharges of suspended solids in municipal sewage.

Region VI (South Central) - The share of suspended solids accounted for by Region VI is expected to drastically decline. This trend is almost entirely the result of abatement initiatives in the bauxite refining phase of aluminum production. Domestic bauxite refining is heavily concentrated in Arkansas and Louisiana. In some of these facilities, immense quantities of "red muds" are released directly to waterborne environments. When the settling ponds required by current EPA legislation are installed, discharges can be essentially reduced to zero. Since these sources represented 65 percent of base year discharges, the impact on regional loadings is substantial.

Region V - The major base year souces of TSS in the Great Lakes area are steel (33 percent), municipal sewage (27 percent), pulp and paper making (11 percent), and asphalt production (87 percent). Discharges from all sources except sewage treatment will decline substantially. The region generally follows national trends.

3.3.3 Oil and Grease

The major source of fats and oil and grease (OAG) is the organic chemicals industry. Trends in OAG discharges are shown in Table XXXVI and Figure 21.

Region VI (South Central) - Region VI is the major contributor to net national OAG discharges, accounting for 27 percent in 1975 and 34 percent in 1990. The organic chemicals sector in this region accounts for 92 percent of the 1975 discharges, and 96 percent of those in 1990. Concentration of the industry in Region VI can be expected to continue and increase because of the presence of essential hydrocarbon feedstocks. In addition, Region VI is one of the fastest growing regions of the country in terms of population and economic activity.

TABLE XXXV

NET REGIONAL DISCHARGES OF SUSPENDED SOLIDS
(10^3 TONS)

	1975		1985									1990								
Federal Region	Base Year	% Total	Base-line[1]	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base	Base-line	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base
I	293	4.1	127	6.5	43.3	127	6.3	43.3	121	6.6	41.3	130	6.2	44.4	130	6.0	44.4	123	6.4	42.0
II	356	5.0	149	7.6	41.9	149	7.4	41.9	143	7.8	40.2	155	7.3	43.5	154	7.1	43.3	146	7.5	41.0
III	755	10.5	216	11.0	28.6	222	11.1	29.4	202	11.1	26.8	228	10.8	30.2	234	10.9	13.2	211	10.9	27.9
IV	1768	24.7	568	28.9	32.1	596	29.8	33.7	506	27.8	28.6	632	30.0	35.7	663	30.9	37.5	559	28.9	31.6
V	1192	16.6	346	17.6	29.0	347	17.3	29.1	331	18.1	27.8	360	17.0	30.2	360	16.7	30.2	339	17.5	28.4
VI	1522	21.2	146	7.4	9.6	146	7.3	9.6	137	7.5	9.0	158	7.5	10.4	157	7.3	10.3	146	7.5	9.6
VII	205	2.9	67	3.4	32.7	66	3.3	32.2	64	3.5	31.2	70	3.3	34.1	69	3.2	33.7	65	3.4	31.7
VIII	239	3.3	84	4.3	35.1	91	4.5	38.1	75	4.1	31.4	96	4.5	40.2	100	4.6	41.8	84	4.3	35.1
IX	508	7.1	191	9.7	37.6	193	9.6	38.0	180	9.9	35.4	209	9.9	41.1	212	9.8	41.7	194	10.0	38.2
X	326	4.6	70	3.6	21.5	69	3.4	21.2	65	3.6	19.9	75	3.5	23.0	75	3.5	23.0	69	3.6	21.2
TOTAL	7164	100.0	1964	100.0	27.4	2006	100.0	28.0	1824	100.0	25.5	2113	100.0	29.5	2154	100.0	30.1	1936	100.0	27.0

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[1] TAMP NEP

TABLE XXXVI

REGIONAL DISCHARGES OF NET OIL AND GREASE
(10^3 TONS)

	1975		1985									1990								
Federal Region	Base Year	% Total	Base-line[1]	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base	Base-line	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base
I	160	6.6	182	7.1	113.8	173	7.0	108.1	164	7.1	102.5	225	7.3	140.6	212	7.2	132.5	203	7.3	126.9
II	389	16.2	441	17.3	113.4	422	17.1	108.5	398	17.2	102.3	523	16.9	134.4	494	16.8	127.0	471	16.9	121.1
III	301	12.5	222	8.7	73.8	213	8.6	70.8	197	8.5	65.4	246	7.9	81.7	233	7.9	77.4	218	7.8	72.4
IV	192	8.0	223	8.7	116.1	214	8.7	111.4	202	8.7	105.2	280	9.0	145.8	265	9.0	138.0	253	9.1	131.8
V	518	21.5	459	18.0	88.6	443	18.0	85.5	416	18.0	80.3	542	17.5	104.6	515	17.5	99.4	488	17.5	94.2
VI	658	27.3	836	32.7	127.1	810	32.9	123.1	757	32.8	115.0	1056	33.9	160.5	1004	34.1	152.6	951	34.0	144.5
VII	36	1.5	25	1.0	69.4	24	1.0	66.7	22	1.0	61.1	28	0.9	77.8	27	0.9	75.0	26	0.9	72.2
VIII	28	1.2	24	0.9	85.7	23	0.9	82.1	22	1.0	78.6	30	1.0	107.1	29	1.0	103.6	27	1.0	96.4
IX	116	4.8	126	4.9	108.6	122	4.9	105.2	113	4.9	97.4	151	4.9	130.2	144	4.9	124.1	135	4.8	116.4
X	10	0.4	18	0.7	180.0	23	0.9	230.0	19	0.8	190.0	21	0.7	210.0	22	0.7	220.0	20	0.7	200.0
TOTAL	2408	100.0	2556	100.0	106.1	2467	100.0	102.5	2310	100.0	95.9	3102	100.0	128.8	2945	100.0	122.3	2792	100.0	115.9

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[1] TAMP NEP

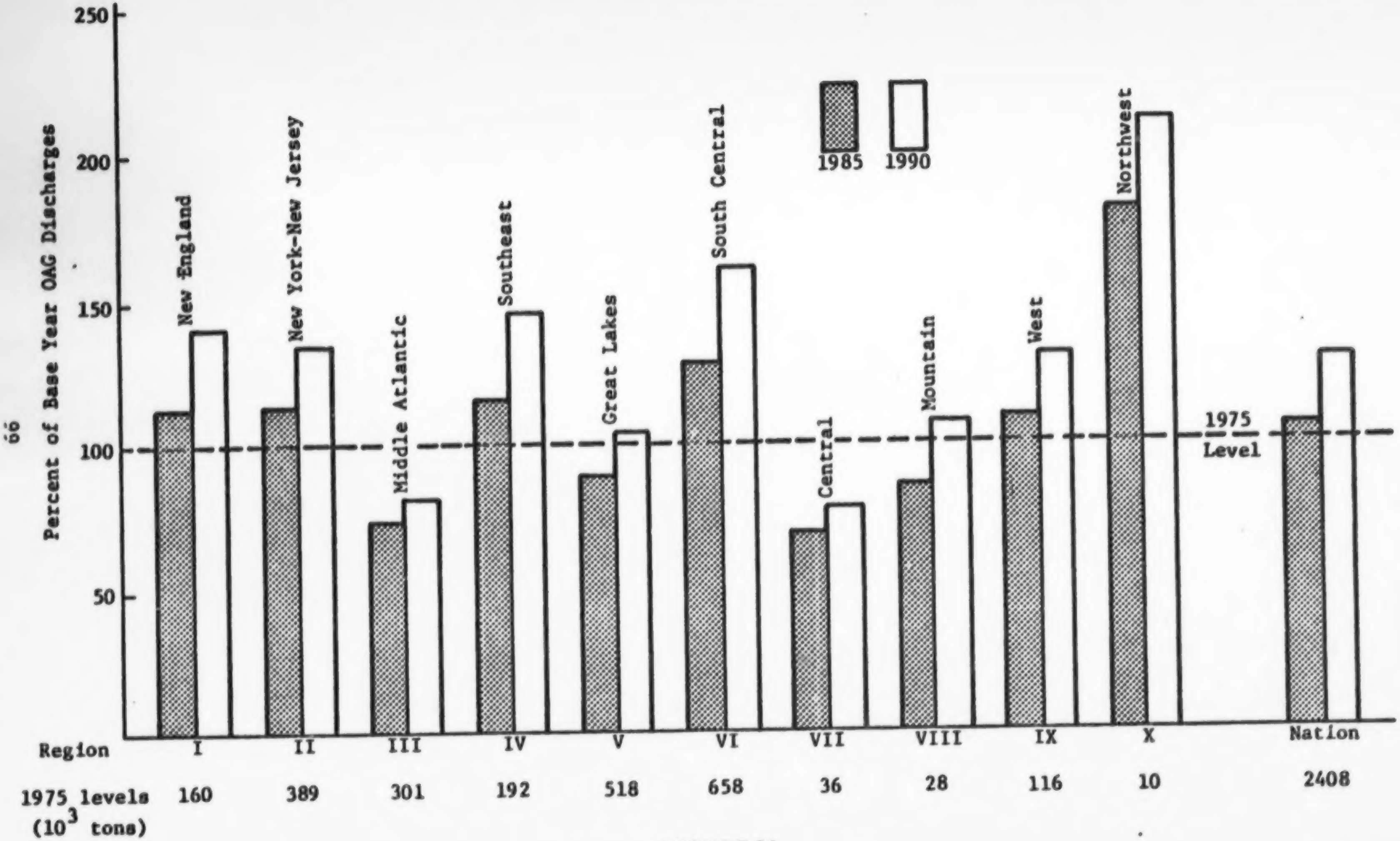

FIGURE 21
TRENDS IN NET OIL & GREASE DISCHARGES BY FEDERAL REGION

Region V (Great Lakes) - Region V experiences a relative decline in net OAG discharges, from 22 percent in 1975 to 18 percent in 1990 as total discharges remain relatively stable over time. Increased effluents from organic chemicals production are offset by declines in the net discharges from steel and meat processing, two other significant contributors to OAG discharges that are heavily controlled under existing abatement legislation.

Region II (New York-New Jersey) - Oil and grease in Region II are discharged almost exclusively by the organic chemicals industry (92 percent in 1975 and 96 percent in 1990).

Region X (Northwest) - The very high growth trend in Region X does not appear significant, given the extremely low base year value.

3.3.4 Biochemical Oxygen Demand

The most widely used parameter of organic pollution is five day biochemical oxygen demand (BOD_5). Determination of BOD involves the measurement of the dissolved oxygen used by microorganisms in the biochemical oxidation of organic matter. An excessive BOD measurement indicates the potential for depletion of dissolved oxygen. This can lead to the anaerobic decomposition of organic materials, and formation of noxious gases.

The BOD measurement is used in sewage treatment and water-quality management to determine the approximate quantity of oxygen that will be required to stabilize organic matter present. BOD data are used to size waste treatment facilities and to measure the efficiency of treatment processes.

At the national level, major contributors to BOD discharges in the base year are municipal sewage, pulp and paper, textiles, and meat processing. As the impacts of federal pollution abatement legislation are felt, municipal sewage and textile sources of BOD will increase in importance, while effluents from pulp and paper operations decline sharply in relative significance.

The regional composition of the waste streams diverges from national patterns. Municipal waste treatment, which accounts for 41 percent of national BOD in 1975, generates less than 25 percent of total BOD in Region IV and X and over 60 percent in Regions II and VI. Paper manufacturing, the second largest contributor nationally (20 percent), is well dispersed throughout the nation. It is the principal source of BOD in Region X (58 percent), and a substantial contributor in Regions II, IV, V and VI. Over 70 percent of textile effluents (which represent 19 percent of the national total of BOD) are concentrated in Region IV, and 90 percent are located in

Regions III, IV, and IX. Industries that are minor residual sources nationally can thus be important within a regional context. These include organic chemicals production in Region VI (12 percent of national totals), sugar refining in Regions VIII (18 percent) and X (6 percent), and meat processing in Region VII (16 percent).

Regional discharge levels for 1975, 1985, and 1990 are shown in Table XXXVII. Regions IV, V, and IX were the largest BOD sources in 1975, accounting for 55 percent of national discharges. The importance of Region IV as an effluent source grows substantially in all scenarios, due to rapid growth in the textile industry which diminishes the effectiveness of legislated controls. The only other region to show increases in its share of national BOD is the Rocky Mountain Region (Region VIII). Region X shows the sharpest decline in residuals output; net discharges drop more than 60 percent. These trends are illustrated in Figure 22. For key regions (IV, V, VIII, IX, X), sector levels trends in BOD generation are discussed in greater detail below.

Region IV (Southeast) - The South's base year contribution of 29 percent of national net BOD discharges far exceeds the region's 1977 share of national manufacturing (12.1 percent) or employment (15.1 percent). Region IV's discharges of BOD increase to as much as 38 percent of the national total of 1990. This trend reflects three major factors:

- Textiles continue to be important to the regional economy. As previously stated, over 70 percent of the BOD discharges recorded for this industry in 1975 occur in this region. Effluents from this sector actually increase 23 percent between 1975 and 1990 despite pollution controls, due to capacity growth. They represent more than two thirds of total discharges in the region by 1990.

- Kraft (sulfate) pulping in the region continues to increase. Paper produced using this pulp is particularly strong and durable, and the pulp can be produced from many woods, including indigenous pines which are unsuitable for other processes.

- Population is expected to shift to Region IV, increasing demand for municipal sewage services. This trend is expected to slow down by 1990, thus it is of lesser significance.

Region V (Great Lakes) - The Great Lakes Region is the second largest contributor to BOD discharges from 1975 to 1990, although the region shows a slight decline over the period. BOD discharges appear to be a function of the region's share of national population (21.7

TABLE XXXVII

REGIONAL DISCHARGES OF NET BIOCHEMICAL OXYGEN DEMAND
(10^3 TONS)

	1975		1985									1990								
Federal Region	Base Year	% Total	Baseline[1]	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base	Baseline	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base
I	225	6.2	139	5.7	61.8	140	5.7	62.2	132	6.0	58.7	143	5.4	63.6	143	5.3	63.6	134	5.6	59.6
II	274	7.5	167	6.9	60.9	166	6.7	60.6	157	7.1	57.3	173	6.6	63.1	172	6.4	62.3	161	6.8	58.8
III	342	9.4	235	9.7	68.7	239	9.6	69.9	217	9.8	63.5	247	9.4	72.2	251	9.3	73.4	227	9.6	66.4
IV	1055	29.0	853	35.2	80.9	907	36.5	86.0	745	33.8	70.6	957	36.3	90.7	1016	37.9	96.3	832	35.1	78.9
V	554	15.1	353	14.6	63.7	351	14.2	63.3	334	15.1	60.3	367	14.0	66.2	364	13.5	65.7	341	14.4	61.6
VI	319	8.8	178	7.4	55.8	177	7.1	55.5	164	7.4	51.4	193	7.3	60.5	193	7.2	60.5	175	7.4	54.9
VII	153	4.2	83	3.4	54.2	81	3.3	52.9	77	3.5	50.3	89	3.4	58.2	87	3.2	56.9	81	3.4	52.9
VIII	102	2.8	84	3.5	82.4	86	3.5	84.3	79	3.6	77.5	96	3.7	94.1	95	3.5	93.1	89	3.8	87.3
IX	385	10.6	235	9.7	61.0	240	9.7	62.3	217	9.0	56.4	263	10.0	68.3	269	10.0	69.9	239	10.1	62.1
X	232	6.4	94	3.9	40.5	92	3.7	39.7	85	3.9	36.6	102	3.9	44.0	100	3.7	43.1	91	3.8	39.2
TOTAL	3641	100.0	2421	100.0	66.5	2479	100.0	68.1	2207	100.0	60.6	2630	100.0	72.2	2690	100.0	73.9	2370	100.0	65.1

[1] TAMP NEP

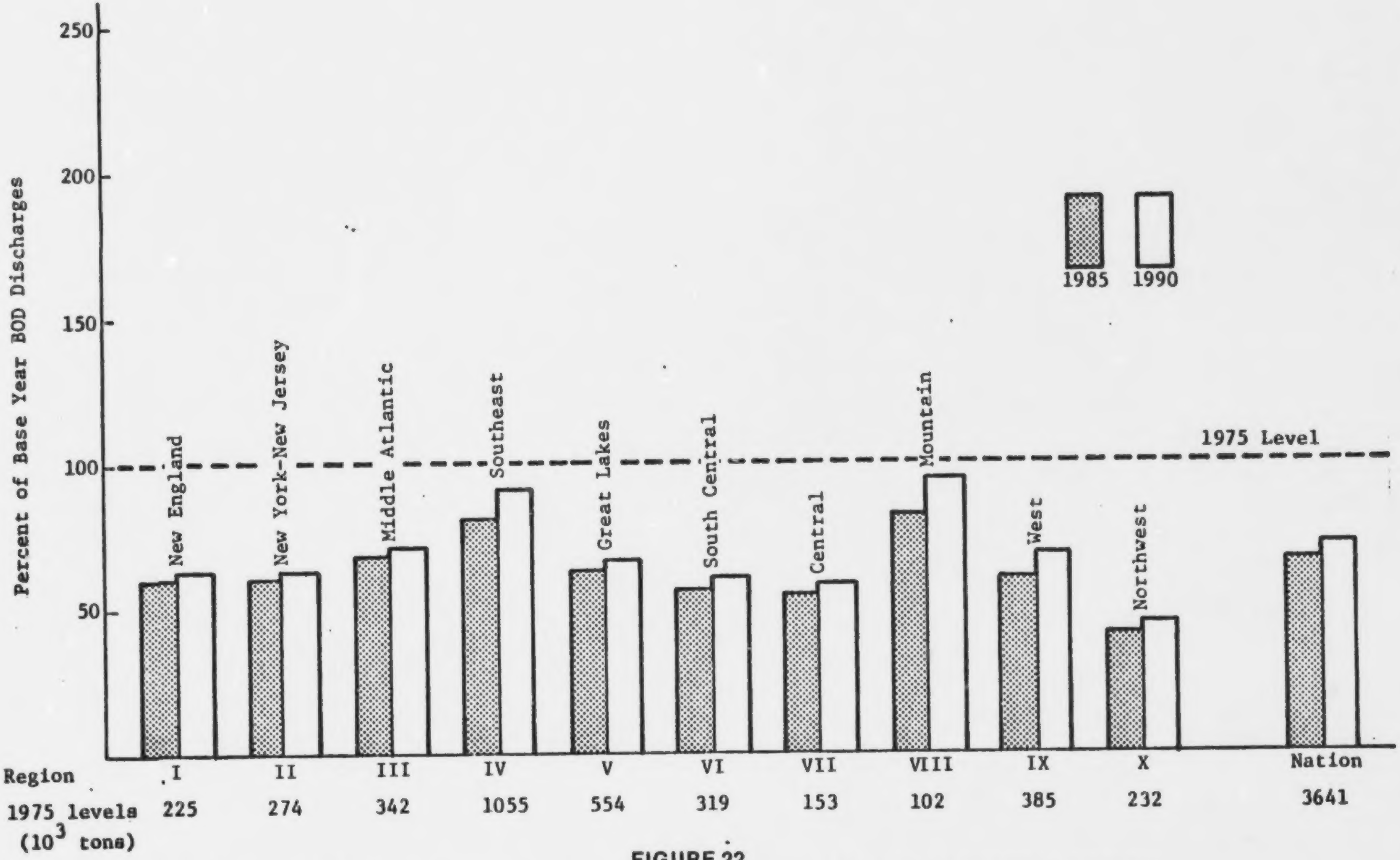

FIGURE 22
TRENDS IN NET BIOCHEMICAL OXYGEN DEMAND DISCHARGES BY FEDERAL REGION

percent in 1977), which affects demand for municipal sewage services, the major source of BOD. Since the region is experiencing a long term decline in population, its contribution to national BOD discharges is expected to decrease.

Region VIII (Mountain) - Base year BOD discharges from Region VIII are consistent with its share of national population. The region's expected growth in BOD discharges from 1975 to 1990 relative to the national rate is due to two factors: development of the synthetic fuels industry, and increased demand for municipal sewage services resulting from high rates of population growth in those states where heavy exploitation of energy resources is expected.

Region IX (West) - The West is the third largest contributor to BOD in all forecast years. Net discharges are forecast to decline faster than the national average rate. Municipal sewage treatment and textiles are the major BOD sources in the region.

Region X (Northwest) - The Northwest, which produced 6.4 percent of total BOD in 1975, is expected to drop to 3.9 percent of the nation's output by 1985. This decline is almost solely due to abatement efforts in the pulp and paper industry. This sector accounted for 58 percent of base year loadings. Although the industry shows continued economic growth in the region throughout the forecast period, pollution controls are expected to reduce effluents from this activity by more than two thirds from 1975 to 1990.

3.3.5 Chemical Oxygen Demand

The COD of wastewaters is generally higher than the BOD because more compounds can be oxidized chemically than biologically. Dissolved oxygen concentrations in a receiving water body may be affected by reaction with these compounds.

Major contributors to net national COD discharges in the base year are textiles, coal-fired electric utilities, organic chemicals, and plastics. There is no significant change in major contributors to 1990, despite improvements in removal efficiencies. Some major water pollution sources such as municipal waste treatment and paper manufacturing are not tested for COD, and therefore are not included in the data base.

As in the case of BOD, the regional mix of sources is quite varied. Textile production, responsible for 73.4 percent of COD nationally, is the principal source of discharges in Regions I (67 percent), II (45 percent), III (74 percent), IV (93 percent), and IX (76 percent). In Region V, coal-fired utilities (28 percent) and organic chemicals (14 percent) are the largest sources, while in

Region VI, the chemicals sector (30 percent) and natural gas-fired power plants (16 percent) are most important. In Regions VII, VIII, and X, the absence of significant amounts of any of these activities results in very low relative COD loadings. Trends in regional effluent outputs are presented in Table XXXVIII and Figure 23.

Discharges from organic chemicals will decline sharply as a result of pollution control initiatives. Emissions from utilities will increase substantially in all regions due to growth in electricity demand and shifts toward increased coal use. Textile effluent streams are controlled in a fairly effective manner through BAT regulations, but the regional rates of change in COD discharges by this sector are distorted by projected shifts in the concentration of industry activity. While textile COD discharges decline more than 65 percent in Region I, where the industry is stagnant, they decline only about 18 percent in Region IV, and actually increase 8 percent in Region IX. Given the significance of this sector to the total waterborne COD emissions of all three regions, the future trends in water quality resulting from this shift may be quite significant.

COD discharges are heavily concentrated in the South due to textile production. This region accounts for about 59 percent of total COD discharge from 1975 to 1990, despite the fact that the region contains only 10 percent of national land area, 16 percent of population, and 12 percent of manufacturing value added. This concentration makes the contributions of other regions appear low. In Regions III and VI, total COD loadings in 1975 and 1990 are more than twice BOD loadings. This disparity is increasing in Region VI. Over longer time frames, the relative importance of coal-fired utilities as a COD source will increase greatly. The impact of this will be felt most in the Southwest (VI), Rocky Mountain (VIII), and West (IX) Regions.

TABLE XXXVIII

REGIONAL DISCHARGES OF NET CHEMICAL OXYGEN DEMAND
(10^3 TONS)

	1975		1985									1990								
Federal Region	Base Year	% Total	Base-line[1]	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base	Base line	% Total	% Base	NEP	% Total	% Base	LEG	% Total	% Base
I	341	3.5	143	2.0	41.9	140	1.9	41.1	127	2.1	37.2	128	1.6	37.5	130	1.6	38.1	117	1.7	34.3
II	397	4.1	279	3.9	70.3	263	3.5	66.2	238	3.9	59.9	285	3.6	71.8	271	3.2	68.3	242	3.6	61.0
III	970	10.0	577	18.1	59.5	598	8.0	61.6	407	8.0	50.2	617	7.7	63.6	630	7.5	64.9	521	7.7	53.7
IV	5719	58.9	4131	58.0	72.2	4484	59.9	78.4	3484	57.4	60.9	4739	59.0	82.9	5115	61.1	89.4	4015	58.9	70.2
V	582	6.0	455	6.4	78.2	444	5.9	76.3	403	6.6	69.2	480	6.0	82.5	459	5.5	78.9	413	6.1	71.0
VI	671	6.9	529	7.4	78.8	524	7.0	78.1	460	7.6	68.6	581	7.2	86.6	570	6.9	86.1	494	7.3	73.6
VII	164	1.7	187	2.6	114.0	178	2.4	100.5	161	2.7	1.0	208	2.6	126.8	195	2.3	118.9	178	2.6	108.5
VIII	101	1.0	167	2.3	165.3	165	2.2	163.4	143	2.4	141.6	189	2.4	187.1	100	2.2	104.1	159	2.3	157.4
IX	680	7.0	589	8.3	86.6	621	8.3	91.3	503	8.3	74.0	715	8.9	105.1	750	8.9	110.3	609	8.8	80.5
X	78	.9	70	1.0	89.7	64	.9	82.1	62	1.0	79.5	78	1.0	100.0	71	.0	91.0	67	1.0	85.9
TOTAL	9703	100.0	7127	100.0	73.5	7401	100.0	77.1	6068	100.0	62.5	8020	100.0	82.7	8385	100.0	86.4	6808	100.0	70.2

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[1] TAMP NEP

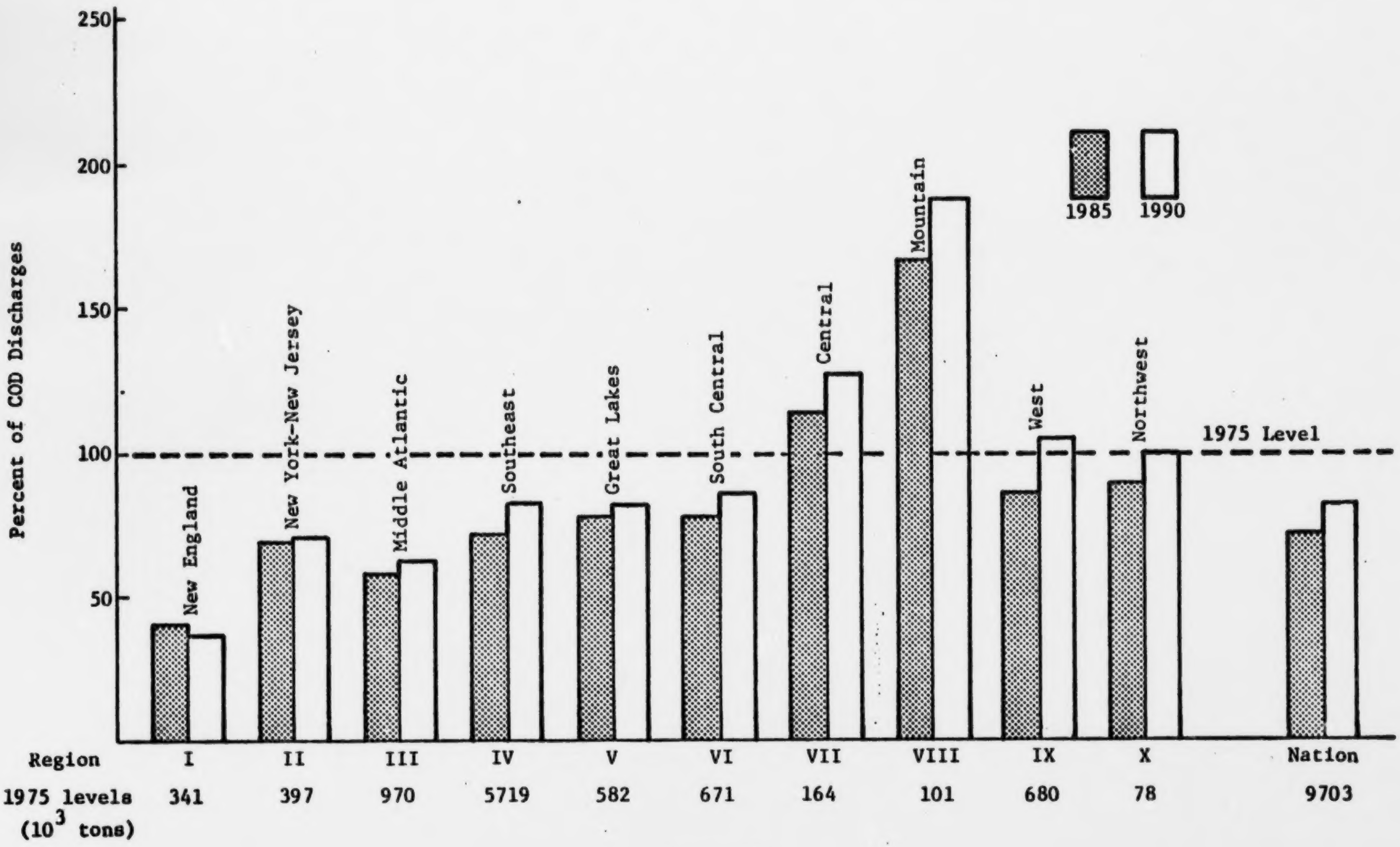

FIGURE 23
TRENDS IN NET CHEMICAL OXYGEN DEMAND DISCHARGES BY FEDERAL REGION

4.0 TOXIC SUBSTANCES

4.1 Air Residuals Data

Emissions of toxic substances from stationary sources are regulated under authority of Section 112 of the Clean Air Act which requires EPA to promulgate national emissions standards for hazardous air pollutants (NESHAP). To date, standards have been set for asbestos, beryllium, mercury, vinyl chloride,[1] and most recently, benzene.

Only three sectors in the SEAS data base (nonferrous metals manufacturing, electric utilities, and the industrial combustion of coal) contain comprehensive data on toxic residuals generation. The primary contributor of toxics in the nonferrous metals manufacturing sector in SEAS is copper smelting, which is consistent with the published literature. SEAS assumptions about toxic emissions from mobile sources, residential and commercial boilers, and municipal incineration correspond fairly closely to other estimates. However, other significant sources of emissions such as iron and steel, ore mining, chemicals, paint, and ink manufacturing are not estimated by SEAS.

This inconsistent coverage seriously impairs the precision of SEAS projections for many of the toxic materials. Only two of the fourteen toxic air constitutents included in SEAS, beryllium and nickel, have good (>67 percent) source coverage, while arsenic, cadmium, manganese and selenium show a fair (33 percent to 67 percent) correspondence with the source listings of independent data bases.

Table XXXIX compares SEAS estimates of total toxics generation with available data from other sources. Only beryllium, cadmium, and nickel show close correspondence with other sources. SEAS estimates for manganese and selenium represent about 50 percent of the other data base totals. More detailed comparisons of the base year inventories are provided below to determine the actual correspondence between estimates for particular industrial sectors.

4.1.1 Beryllium

Beryllium has been used as an industrial material since the 1920s. It is alloyed with other metals to impart desirable qualities such as greater tensility or increased resistance to fatigue. Beryllium is widely used in general machine parts, nuclear reactors, and aerospace and electronic components. U.S. consumption has grown from

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[1] 40 CFR 61

TABLE XXXIX

COMPARISON OF BASELINE TOXIC AIR RESIDUAL EMISSIONS (TONS PER YEAR)

Residual Component	SEAS (1975)	Other Data Sources
Antimony	16	350 (1970)[1]
Arsenic	2,632	9,415 (1968)[2]
Asbestos	240	6,844 (1973)[3]
Beryllium	128	144 (1973)[3]
Cadmium	1,308	1,552 (1977)[4] 2,284 (1971)[2]
Copper	709	13,910 (1969)[2]
Lead	2,871	184,316 (1968)[4] 190,338 (1973)[3]
Manganese	9,951	18,992 (1968)[2]
Mercury	303	800 (1970)[1]
Nickel	4,880	6,000 (1968)[2]
Selenium	562	1,215 (1970)[4]
Zinc	172	159,922 (1969)[2]

SOURCES:

[1] U.S. Bureau of Mines. Mineral Facts and Problems, 1970.

[2] U.S. Environmental Protection Agency. National Inventory of Sources and Emissions - 1969, (set of material specific studies).

[3] Goldberg, A.J. A Survey of Emissions Control for Hazardous and Other Pollutants, Air Pollution Technology Branch, Office of Research and Monitoring, U.S. Environmental Protection Agency, February 1973.

[4] National Academy of Sciences. Lead: Airborne Lead in Perspective, Washington, D.C.: Committee on Biologic Effects of Atmospheric Pollutants, 1972 (other materials have similar citations).

around 5,000 short tons per year in the early 1960s to twice that level in the early 1970s.

Beryllium is one of the most hazardous materials in industrial use. Fortunately, the metal's high value acts as an inducement to control and reclaim beryllium from industrial waste streams.

A study conducted for EPA has inventoried and quantified point sources of beryllium emissions.[1] The findings are given in Table XL and are compared to estimates from the current SEAS data base. A comparison of EPA and SEAS data bases shows them to be in general agreement with respect to major sources of beryllium and their relative contributions.

4.1.2 Cadmium

Cadmium is found as a trace element in zinc bearing ore. Copper and lead ore also contain small amounts of cadmium. Cadmium is released to the environment during the extraction and refining of these metals. Cadmium is also discharged during industrial activities which require its use: electroplating automotive and aircraft parts, alloying metals, manufacturing paints and plastics, reclaiming scrap steel, and curing rubber. The extent to which most sources discharge cadmium to the environment is not well known. Air emissions are better understood than emissions to land or water.

Cadmium is recovered as a by-product during the extraction and metallurgical processing of zinc, lead, and copper. Cadmium emissions from metallurgical processes and industrial activities using cadmium as raw material are significant. Cadmium emission estimates from a variety of studies are shown in Table XLI.

The data for individual sector emissions show little agreement except for cadmium emissions from the production of zinc. The SEAS total emission estimates are generally low in comparison with the other studies.

4.1.3 Manganese

Over 100 minerals contain manganese as a natural constituent. Among the minerals containing manganese are sulfides, anhydrous and hydrous oxides, carbonates, anhydrous and hydrous silicates,

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[1] Goldberg, A.J., A Survey of Emissions Control for Hazardous and Other Pollutants, Air Pollution Technology Branch, Office of Research and Monitoring, U.S. Environmental Protection Agency, February 1973.

TABLE XL

COMPARISON OF SOURCES AND QUANTITIES OF BERYLLIUM EMISSIONS
(TONS PER YEAR)

Source	SEAS (1975)[1]	Percent Contribution	EPA (1973)[2]	Percent Contribution
Aray Iron Foundry	--	--	4	2.8
Beryllium Alloys and Compounds Production	6.501	5.1	5	3.5
Power Plant Boilers	73.494	57.4	101	70.1
Industrial Boilers	48.038	38.5	25	17.4
Residential and Commercial Boilers	--	--	9	6.3
Sewage Sludge Incineration	0.002	<0.01	--	--
Total	128.035	100.0	144	100.0

[1] TAMP NEP - Revised July 1978 - Net Residuals.

[2] Goldberg, A.J. A Survey of Emission Control for Hazardous and Other Pollutants. Air Pollution Technology Branch, Office of Research and Monitoring, U.S. Environmental Protection Agency. February 1973.

TABLE XLI

NET ATMOSPHERIC CADMIUM EMISSIONS
(TONS)

	Reference Document - Estimate Year				
Emission Source	1975[1]	1971[2]	1968[3]	1977[4]	1968[5]
Sewage Sludge Incineration	0.005*	137.8	1220.0	5.5	
Municipal Incineration	6.104*	48.5	1220.0	34.1	1019.0
Copper Smelting	46.084*	233.7		20.9	25.0
Copper Smelting w/Roaster	15.181	233.7			
Copper Smelting w/o Roaster	14.445	233.7			
Primary Lead	69.427*	163.15		20.9	25.0
Secondary Lead	0.080*	65.05			
Primary Zinc	745.459*	643.95	1050.0	1005.4	1000.0
Electric-Coal-Old	11.353*	80.45		258.5	
Electric-Oil-Old	315.344				
Sub-Total	326.697				
Industrial-Coal-Old	5.217*	19.85			
Industrial-Residual Oil-Old	79.158	59.50	0.91	39.6	
Sub-Total	84.375	79.35			

TABLE XLI (Concluded)

	Reference Document - Estimate Year				
Emission Source	1975[1]	1971[2]	1968[3]	1977[4]	1968[5]
Secondary Zinc		20.95			
Cement Production				35.2	
Paints				11.0	
Cadmium Processing		59.95			
Reclaiming Steel Scrap		78.05		110.0	
Coke Ovens		37.5			
Plastics			3.0	3.3	
Alloying		1.2	2.5	2.2	
Other Reprocessing (e.g. batteries, pigments)		0.5	0.76		
Misc. Consumptive Uses (e.g. fertilizers, fungacide, rubber tire use)		5.7	6.4	5.5	5.2
Total	1307.857	1655.8	2283.57	1552.1	2074.2

*Controlled

[1] SEAS, EIA Scenario - 1975

[2] "Scientific and Technical Assessment Report on Cadmium," Star Series

[3] "National Inventory of Sources and Emissions: Cadmium - 1968"

[4] "Hazardous Wastes: A Risk Benefit Framework Applied to Cadmium and Asbestos"

arsenates, tungstates, and borates. Oxides, carbonates, and silicates are the most important. The chlorides, nitrates, and sulfates of manganese are highly soluble in water, but the oxides, carbonates, and hydroxides are only slightly soluble.

Table XLII compares the SEAS estimate manganese discharged to the air with estimates from two other data sources.

The SEAS model estimates total manganese emissions to be 9,951 tons per year, roughly half of the other estimates. The emission factors for coal consumption are higher in the SEAS model than in the other studies. However, other important sources such as manganese alloy processing are omitted.

4.1.4 Nickel

Nickel has a variety of uses and is vital to the metals industries. In alloys, it lends resistance to corrosion and additional strength; more than 90 percent of nickel consumed goes into alloys. In batteries, dyes, and pigments, nickel acts as a catalyst. The element is also used in insecticides. Nickel is one of a group of metals exhibiting anti-knock properties in gasoline.[1]

The toxicity of nickel has been documented through epidemiological and occupational studies linking the metal to cancer and other diseases such as nickel dermatitis and nickel carbonyl poisoning.[2] Primary consumers of nickel are the steel industry for the production of stainless and alloy steels), electroplating, and other alloy manufacturers.

Based on 1968 to 1970 data, productive and consumptive processes have been estimated to emit 6,000 tons of nickel particulates to the air per year.[3] Net nickel residuals are expected to rise at an average rate of 8.6 percent per year.

SEAS provides estimates of nickel air emissions for several sectors of the economy: municipal incineration (0.5 percent), copper

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[1] Washington Environmental Research Center. Development of Predictions of Future Pollution Problems. Prepared for Office of Research and Development, EPA-600/5-74-005, U.S. Environmental Protection Agency, Washington, D.C., March 1974.

[2] National Academy of Sciences. Nickel. Committee on Medical and Biologic Effects of Environmental Pollutants, Washington, D.C., 1975.

[3] Davis, W.E. and Associates. National Inventory of Sources and Emissions: Cadmium, Nickel and Asbestos, Section I-II (1968-1970).

TABLE XLII

NET DISCHARGES OF MANGANESE TO AIR
(TONS)

Source	1968[1]	1968[2]	SEAS (1975)[3]
Mining	5	5	---
Processing			
Manganese Metal	290	325	---
Manganese Alloys	8,050	8,946	---
Reprocessing			
Cuban Steel	3,910	4,340	---
Cast Iron	2,490	2,770	---
Welding Rods	20	24	---
Nonferrous Alloy	50	60	---
Batteries	80	90	---
Chemicals	270	300	---
Consumptive Uses			
Coal	1,760	1,950	9877.166
Oil	6	7	19.105
Incineration			
Sewage and Sludge	160	175	55.153
Total	17,091	18,992	9951.424

[1] U.S. Environmental Protection Agency. Scientific and Technical Report on Manganese, EPA-600/6-74-002, Research Triangle Park, North Carolina, April 1975.

[2] W.E. Davis and Associates. National Inventory of Sources and Emissions: Manganese - 1968, APTD-1509, August 1971.

[3] TAMP NEP - Revised, July 1978.

smelting (0.01 percent), electric utilities (70.8 percent), industrial oil combustion (25.0 percent), residential and commercial oil combustion (0.1 percent), and combustion of gasoline by automobiles (3.5 percent).

4.1.5 Selenium

Selenium is produced as a by-product in copper refining. Although selenium is produced in relatively small quantities, it is widely used in several sectors of the economy. Selenium is used in the production of rectifiers and photo cells, in xerography, in stainless steel production and chromium plating, in glass and ceramics for color, tinting, and glare reduction, in pigments for plastics, paints, enamels, inks, and rubber, and in pharmaceuticals. Selenium is also used in the production of pesticides and as an additive to animal feed.

SEAS considers selenium emissions from copper smelting, and the combustion of coal by electric utilities and by industrial boilers. Estimates are given in Table XLIII. Discharges of selenium to the air for 1975 are estimated to approach 562 tons. According to another study by the National Academy of Sciences, selenium emissions in 1970 amounted to 1,215 tons. This study covered more sources of emissions than SEAS. Zinc and selenium refining, and glass and ceramic manufacturing are the most important omissions in the SEAS system.

4.2 Water Residuals Data

Toxic metal pollution has been cited as a significant water quality problem by a majority of states.[1] Thirty-five of forty-one states reported toxics to be problems in 1976, with fewer citing pesticides, phenols, cyanide, and PCBs (see Table XLIV). Current estimates indicate that more than 42,000 industrial and agricultural establishments discharge their effluents to surface waters directly[2] and more than 55,000 to publicly owned wastewater treatment works.[3] The former are subject to the NPDES program and the

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[1] Environmental Quality - 1977. Executive Office of the President, Council on Environmental Quality, Washington, D.C., December 1977, p. 240.

[2] Environmental Quality - 1977. Executive Office of the President, Council on Environmental Quality, Washington, D.C., December 1977, p. 35.

[3] Environmental Technology Consultants, Local Pretreatment Program Requirements. Prepared for EPA Joint Municipal/Industrial Wastes, Springfield, VA, May 1978.

TABLE XLIII

COMPARISON OF NET SELENIUM EMISSIONS BY SOURCE
(TONS PER YEAR)

Source	SEAS (1975)[1]	NAS (1970)[2]
Mining and Milling		
Copper	---	
Lead	---	
Zinc	---	5
Phosphate	---	
Uranium	---	
Smelting and Refining		
Copper	31	
Lead	---	250
Zinc	---	
Selenium	---	66.5
Glass and Ceramics	---	65
Electronics and Duplicating	---	0.5
Pigments	---	0.5
Iron and Steel Alloys	---	12.5
Coal Combustion	530	750
Oil Combustion	---	65
Incineration	---	---
Other	---	---
Total	561	1215

[1] TAMP NEP, Revised July 1978.

[2] National Academy of Sciences. Selenium. Committee on Medical and Biologic Effects of Environmental Pollutants, Washington, D.C., 1976.

TABLE XLIV

TOXIC POLLUTANT PROBLEMS IN REPORTING STATES, 1976

	Heavy Metals	Pesticides	Phenols	Cyanide	PCBs
Alabama		o			
Alaska					
Arizona	o				
Arkansas	o	o			
California	o	o			
Colorado	o				
Connecticut	o	o			o
Delaware	o		o		
Florida	o				
Hawaii	o				
Idaho	o	o			
Illinois	o	o	o	o	o
Indiana	o		o	o	o
Kansas					
Kentucky	o				
Maine	o	o	o		
Maryland	o				
Massachusetts	o	o			o
Michigan	o	o	o		o
Minnesota	o		o		o
Mississippi	o	o			
Missouri	o				
Montana	o	o			
Nevada	o			o	
New Hampshire		o			
New Mexico	o				
New York	o	o	o		o
North Carolina	o		o		
Ohio	o	o	o	o	
Oklahoma	o			o	
Pennsylvania	o				
South Carolina	o				
Tennessee	o	o	o	o	
Texas	o	o			
Utah	o				
Vermont					
Virginia	o	o			
Washington					
West Virginia	o		o		
Wisconsin	o	o			o
Wyoming	o				

Source: Environmental Protection Agency. National Water Quality Inventory: 1976. Report to Congress (Washington, D.C., Government Printing Office, 1977), EPA-440/9-76-024, p. 12.

latter to national pretreatment regulations, both of which restrict the discharge of toxic substances.

The Effluent Guidelines Division is developing data on the constituents of the wastewaters of 21 industrial categories, of concern because of the presumed composition of their discharges. These industries are listed in Table XLV. Although discharge estimates have not yet been established, major pollutant discharges in each of the 21 industries' effluents have been identified,[1] and can be compared to corresponding SEAS estimates. SEAS estimates appear to be based on a fairly comprehensive source listing. However, effluents from petroleum refining, machines and mechanical products manufacturing are not estimated in the model. Coverage also is sparse for industries such as laundries and rubber processing, for which identification of toxic waste stream constituents has not been accomplished by EPA. SEAS deals comprehensively with toxics from energy processing activities such as coal mining and electric power generation, electroplating operations, and textile mills. For the iron and steel and chemical processing industries, SEAS coverage of toxic effluents exceeds the current scope of the EPA listings.

In general, estimates for arsenic, chromium, copper, cyanide, lead, and selenium appear to be most complete. Estimates for cadmium, mercury, and phenols appear most doubtful.

Comparative data sources for base year discharges are available for only two toxic elements, cadmium and mercury.

Comparison shows only that considerable uncertainty exists about the level of current discharges. Given the status of existing data base development, it is impossible to resolve these controversies in favor of either SEAS or other sources. Consequently, SEAS projections for even those toxic pollutants categorized as well-covered must be considered as quite tentative.

4.3 Solid Waste Data

Hazardous solid wastes are a subject of growing concern because of the number of hazardous chemicals used in productive processes, anticipated increases in industrial activity, and the increasing number of environmental regulations. The management of sludges is an issue of national environmental significance.

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[1] Effluent Guidelines Division. Effluent Guidelines Program for Pretreatment. Prepared for EPA Joint Municipal/Industrial Seminar on Pretreatment of Industrial Wastes, U.S. EPA, Washington, D.C., 1978.

TABLE XLV

INITIAL 21 INDUSTRIES OF CONCERN

Automatic and Other Laundry
Coal Mining
Electroplating
Inorganic Chemicals Manufacturing
Iron and Steel Manufacturing
Leather Tanning and Finishing
Machinery and Mechanical Products Manufacturing
Miscellaneous Chemicals Manufacturing
Nonferrous Metals Manufacturing
Ore Mining
Organic Chemicals Manufacturing
Paint and Ink Formulation and Printing
Paving and Roofing Materials
Petroleum Refining
Plastic and Synthetic Materials Manufacturing
Pulp and Paperboard Mills and Converted Paper Products
Rubber Processing
Soap and Detergent Manufacturing
Steam Electric Power Plants
Textile Mills
Timber Products Processing

Anticipated national pretreatment regulations for existing and new sources of industrial pollution will sharply restrict the discharge of incompatible toxic waste streams to publicly-owned wastewater treatment systems. These regulations, coupled with NPDES restrictions imposed on direct dischargers, will require industry to remove significant quantities of toxics from all its waste streams.

The Office of Solid Waste Programs at EPA conducted a series of studies attempting to identify the hazardous constituents of land-destined wastes from selected industries. Generally, correspondence between SEAS and data from the Office of Solid Waste Programs is poor. For example, where the Office of Solid Waste Programs estimates the incidence of toxic metals in the sludges of the storage and primary batteries, textiles, petroleum refining, pharmaceutical, special machinery manufacturing, electronic components manufacturing, and petroleum refining industries, SEAS does not. Conversely, SEAS estimates captured residuals in the paint and allied products, organic chemicals, rubber and plastics, and electric utilities industries where comparable data from outside have not yet been identified or released. SEAS coverage of the solid waste components of the inorganic chemicals, electroplating, and metal smelting and refining industries is largely in agreement with estimates from the Office of Solid Waste. Problems of correspondence between the two sources are attributable to definitional differences (for example, in industrial categories only an approximate mapping between SEAS and Office of Solid Waste sectors can be attempted), and the absence of a secondary residuals data base in SEAS. This basic difference between definitions of solid waste also precludes the quantitative validation of SEAS' captured residuals data.

4.4 Forecasts of Toxic Residuals Discharges

Forecasts of toxic discharges reveal significant changes in magnitude and relative contributions by industry over the forecast period. These trends provide some insight into future potential areas of concern. Changes to aggregate output levels between 1975 and 1990 are shown in Table XLVI. Baseline scenario forecasts of net atmospheric emissions, net toxic discharges to water, and total captured residuals from the treatment of stack gases and wastewaters are expressed as a percentage of 1975 values. These statistics reveal that net atmospheric emissions of toxic metals from industrial sources are generally expected to increase over the next 20 years. However, emissions of several airborne toxics, including beryllium, manganese, and nickel, are expected to decline. Conversely, discharges of toxic substances to water decline for all compounds except selenium. Over the forecast period, abatement efficiencies are expected to increase, and a greater proportion of residuals will be

TABLE XLVI

ESTIMATED DISCHARGES OF TOXIC SUBSTANCES BY ALL SECTORS - 1990
(AS A PERCENTAGE OF 1975 VALUES)
(BASELINE SCENARIO)

Toxic Substance	Net Atmospheric Emissions	Net Discharges[1] to Water	Captured Toxics
Arsenic	NA	12.5	200.0
Asbestos	NA	NA	175.0
Beryllium	45.4	NA	333.2
Cadmium	144.5	NA	177.0
Chromium	NA	85.3	243.6
Copper	NA	1.3	538.5
Cyanide	NA	42.5	222.0
Lead	NA	4.1	188.0
Manganese	59.8	NA	216.0
Nickel	88.7	NA	167.0
Selenium	186.4	107.4	258.0

[1] Dissolved Solids

NA - SEAS results not applicable

removed from the waste streams. The presence of large quantities of toxics in industrial sludges could therefore be a problem in the future.

Major point sources which significantly affect toxic substances releases are shown in Tables XLVII, XLVIII, and XLIX. Major contributors to increased toxic emissions to the atmosphere are those industries associated with nonferrous metals manufacture, older oil-fired industrial boilers, and municipal refuse and sewage sludge incinerators. Higher emissions from these sectors reflect projected economic growth and associated output levels which more than compensate for gains in abatement efficiency instituted over the forecast period. Abatement of emissions from copper smelting is expected to remain a problem over the period of analysis, as removal efficiencies are not expected to improve from 1975 to 1990. Increases in output of copper are expected to cause corresponding increases in emission of toxic metals.

Toxic emissions associated with the combustion of coal by industry and electric utilities are expected to decline significantly over the forecast period as older boilers are replaced by new facilities which must conform to BACT standards. Removal efficiencies of coal fired electric utilities are expected to increase from 87 percent in 1975 to 95 percent in 1990; particulate removal from the exhaust gases from coal burning industrial boilers are expected to increase from 59 percent to 95 percent over the same period. These efficiency gains more than offset growth in the use of coal as an energy source. Given the differences in both economics and energy use in the three scenarios, considerable variation should be expected between forecasts. This is discussed in greater detail below.

Differences in emissions of toxics from electric utilities and industrial boilers are attributable to different rates of substitution of coal for oil in these sectors. The combustion of oil in industrial boilers is expected to increase gradually over the forecast period from 2.4 quadrillion Btus (quads) per year in 1975 to 4.9 quads in 1990 (an average growth rate of approximately 5 percent annually). Oil-fired electric utility capacity is expected to decline from 1.1 quads in 1975 to 0.7 quads in 1990. Therefore, changing energy activity levels are accounting for significant differences in residuals output.

With respect to water pollutants (see Table XLVIII), growth in net discharges of toxics is expected in the following industrial sectors: aluminum, other nonferrous metals (primarily lead and zinc production), organic chemicals, and coal preparation. Emissions increases from aluminum are attributable to high growth in that industry over the forecast period (Table L). Table L reveals that

TABLE XLVII

DISCHARGES OF TOXICS TO THE ATMOSPHERE FROM SELECTED SOURCES - 1990
(EXPRESSED AS A FRACTION OF 1975 ESTIMATE)
(BASELINE SCENARIO)

	Beryllium	Cadmium	Manganese	Nickel	Selenium
Non-Ferrous Metals					
Copper		1.50		1.50	1.50
Lead		1.73			
Zinc		1.79			
Industrial Chemicals					
Electric Utilities					
Coal	0.41	0.66	0.76		1.94
Oil	0.65	0.65	0.65	0.65	
Industrial Boilers					
Coal	0.16	0.30	0.33		1.74
Oil	1.54	1.54	1.54	1.54	
Residential and Commercial					
Oil			0.90	0.90	
Incineration	3.00	1.37	1.40	1.37	
Mobile Sources - Gasoline				0.89	
Other	2.05				

TABLE XLVIII

NET DISCHARGES OF TOXICS TO WATER[1] FROM SELECTED SOURCES - 1990
(EXPRESSED AS A FRACTION OF 1975 VALUE)
(BASELINE SCENARIO)

	Arsenic	Chromium	Copper	Cyanide	Lead	Selenium
Copper	0.0	0.0	0.0	0.0	0.0	
Aluminum			1.83	1.86	0.03	
Other Non-Ferrous Metals	1.21		0.47	1.79	1.66	1.21
Inorganic Chemicals	1.06	0.0	0.65		0.0	
Organic Chemicals		1.75	1.53	0.29		
Paints			0.0		0.0	
Rubber		1.70				
Plastics		2.59				
Textiles		2.32				
Electroplating		0.0	0.0	0.0		
Cement		0.0			0.0	
Steel		0.01		0.06	0.06	
Coal Mining						
Coal Preparation						
Coal-Synthetic Fuels		o		o		
Electric Utilities						
Old/Coal		0.02	0.0			
New/Coal		o		o		
Oil		0.01	0.0			
Natural Gas		0.01	0.0			
Nuclear						

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[1] as dissolved solids

o denotes increase from zero discharges

TABLE XLIX

CAPTURED TOXICS FROM INDUSTRIAL WASTEWATERS - SELECTED SOURCES - 1990
(EXPRESSED RELATIVE TO 1975 VALUE)
(BASELINE SCENARIO)

	Arsenic	Chromium	Copper	Cyanide	Lead	Selenium
Copper	2.12	2.12	2.12	2.11	2.12	2.14
Aluminum			6.36		4.61	
Other Non-Ferrous Metals	o		2.19		2.19	o
Inorganic Chemicals	1.69	2.25		2.59		
Organic Chemicals			2.65	2.25		
Paints			3.35		3.35	
Rubber						
Plastics						
Textiles						
Electroplating		2.07	1.90	1.77		
Cement		3.02			3.02	
Steel		2.28		2.70	3.26	
Coal Mining						
Coal Preparation						
Coal-Synthetic Fuels	o	o	o	o		
Electric Utilities						
Old/Coal		o	4.90			
New/Coal	o	o	o	o		
Oil		o	3.59			
Natural Gas		o	1.34			
Nuclear		o	24.90			

[1] as dissolved solids

o denotes increase from zero discharges

TABLE L

COMPARISON OF GROWTH IN OUTPUT BY ALUMINUM INDUSTRY WITH NET INCREASES OF TOXIC DISCHARGES TO WATER (1975-1990) (BASELINE SCENARIO)

	1975	1985[1]	1990[2]
Output (Millions of $)	8,141.8	14,670.0 (6.1)	19,509.6 (5.9)
Net Discharges to Wastewater (tons)			
Copper	12.8	19.5 (4.3)	23.4 (3.7)
Cyanide	8.1	12.4 (4.4)	15.0 (3.9)
Nickel	43.3	66.5 (4.4)	80.1 (3.8)
Zinc	67.6	103.2 (4.3)	124.3 (3.8)
Lead	0.1	--- (---)	--- (---)
Manganese	0.3	--- (---)	--- (---)

[1] Average annual growth rates 1975-1985 in parenthesis.

[2] Average annual growth rates 1985-1990 in parenthesis.

output increases negate any gains in abatement efficiency. Discharges of lead and manganese are eliminated over the time period, although reduced from insignificant base year levels.

Like the aluminum industry, growth in organic chemicals production is responsible for greater discharges of toxics to wastewaters from that sector in 1990. Removal efficiencies of copper and phenols, although improved from 1975 to 1985, fail to stem increased residuals production due to higher output levels. Only cyanide is successfully abated.

Table LI also reveals the environmental impacts of new technologies associated with an emphasis on using coal. Higher net discharges of manganese and zinc to water are expected to be associated with coal cleaning, which is employed to reduce the sulfur content of coal. The manufacture of synthetic fuels from coal will result in discharges of chromium, cyanide, and zinc. Improved abatement efficiencies from 1975 to 1985 successfully counteract sectoral growth and corresponding discharges over this period. However, no further efficiency gains are foreseen beyond 1985 and residuals growth is expected to increase at rates similar to economic growth in these sectors.

Zero discharge levels are expected to be achieved in the copper, paint, electroplating, and cement industries. Zero discharge of all toxics except arsenic and copper are also expected in the inorganic chemicals industry, and nearly insignificant emission levels are forecast for steel production by 1990.

With respect to atmospheric emissions, the growing importance of the "other nonferrous metals" sector is seen in beryllium emissions, where its share of total emissions changes from 5 percent in 1975 to 23 percent in 1990. This is attributable to absolute increases in beryllium emissions from this sector (average annual growth in emissions approaches 5 percent) at the same time that total net emissions are declining (average decrease of 5 percent per year).

Changing sectoral contributions of toxic discharges to water are primarily attributable to successful abatement practices in the copper, electroplating, inorganic chemicals, steel, and electric utilities sectors, and greater quantities of residuals generated by organic chemicals, other nonferrous metals, and coal mining, coal cleaning, and synfuels. The inorganic chemicals sector becomes the predominant discharger of arsenic to water only because a zero emissions level is reached by the copper industry. Similarly, the organic chemicals sector becomes the important contributor of cadmium because of zero emissions attained by the electroplating sector.

TABLE LI

COMPARISON OF GROWTH IN COAL CLEANING AND SYNTHETIC FUEL PRODUCTION WITH NET DISCHARGES OF TOXICS TO WATER (BASELINE SCENARIO)

	1975	1985[1]	1990[2]
I. Coal Cleaning			
Output (10^{15} Btus)	6.5	10.98 (5.4)	14.47 (5.7)
Net Residuals Output (Tons)			
Manganese	462.8	363.2 (-2.4)	478.2 (5.7)
Nickel	28.2	27.4 (-0.6)	36.1 (5.7)
Zinc	49.7	50.8 (0.0)	66.9 (5.7)
II. Coal Synthetic Fuels	0.0	0.32	1.06
Output (10^{15} Btus)		(*)	(27.1)
Net Residuals Output (Tons)			
Chromium	0.0	0.0 (0.0)	44.9 (*)
Cyanide	0.0	827.4 (*)	1607.7 (14.2)
Zinc	0.0	0.0 (0.0)	22.1 (*)

[1] Average annual growth rates 1975-1985 in parenthesis.

[2] Average annual growth rates 1985-1990 in parenthesis.

*Not applicable.

In response to more stringent environmental regulations concerning pollutant discharges to air and water, toxic particulates and dissolved solids are forecast to be removed more effectively from waste streams over the period of analysis. These higher removal efficiences are reflected in the relative increases in captured toxics as shown in Table LII. In all cases, greater quantities of captured residuals are expected. The magnitudes are influenced by both changes in removal efficiencies and economic growth.

Contributions from various pollution sources do not differ vastly among scenarios. Differences between the LEG scenario and the other two scenarios are attributable primarily tc lower retirement of older coal, oil, and natural gas boilers. Higher coal utilization in the NEP scenario accounts for higher generation of associated toxics (arsenic, beryllium, chromium, cyanide, selenium, and lead).

The major difference in emissions among scenarios concerns emissions of selenium. Table LIII shows that differences in the industrial combustion of coal are primarily responsible for significantly different output levels of selenium emissions among scenarios. By 1990, industrial boilers are forecast in the NEP scenario to consume 8.5 quads through the combustion of coal compared with 5.1 quads in the Baseline scenario and 3.3 quads in the LEG scenario. Conversion to coal by industry is inhibited in the LEG scenario. A greater percentage of older capital stock (a smaller proportion of which generates selenium emissions) is therefore retained. Absolute levels of selenium emissions are further reduced in the LEG scenario because of lower levels of output by industry.

The impact of accelerated development of synfuels from coal, encouraged in the National Energy Plan,[1] can be most clearly seen in forecasts of cyanide emissions. The NEP scenario assumes almost twice as much energy supplied in 1985 by high quality fuels derived from coal than does the Baseline scenario (0.6 versus 0.3 quads), and 50 percent more in 1990 (1.05 versus 0.70 quads). Resultant gross pollutant loadings of cyanide to water are 136 percent greater in 1985 and 60 percent higher in 1990. Reflecting less development of synthetic fuel, the LEG scenario shows the lowest discharges of cyanide to water. Total discharges in all scenarios are declining over the forecast period relative to 1975. As described above, this is primarily due to the introduction of more efficient abatement technologies into the treatment systems of other industrial sectors, notably electroplating and steel.

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[1] Executive Office of the President. The National Energy Plan. Energy Policy and Planning, U.S. GPO, Washington, D.C., 1977.

TABLE LII

CAPTURED RESIDUALS GENERATED BY SELECTED ENERGY TECHNOLOGIES (TONS) (BASELINE SCENARIO)

Source/Toxic	1975	1985	1990
Coal Mining			
Manganese	4244.7	7562.9	8385.7
Nickel	181.1	344.2	389.9
Zinc	461.0	872.8	987.0
Coal Preparation			
Manganese	1025.5	2138.6	2810.0
Nickel	46.7	98.9	130.3
Zinc	311.9	559.7	737.1
Coal-Synthetic Fuels			
Arsenic	0.0	0.7	1.6
Chromium	0.0	0.1	45.2
Copper	0.0	0.5	1.0
Cyanide	0.0	1930.5	3751.2
Nickel	0.0	0.7	1.5
Zinc	0.0	1.4	25.3
Electric Utilities-Old/Coal			
Arsenic	3036.6	2979.6	2927.9
Beryllium	508.1	523.8	514.5
Cadmium	79.1	80.6	79.1
Chromium	0.0	1058.9	1040.4
Copper	5073.5	25301.2	24859.7
Lead	3968.1	3813.3	3748.0
Maganese	40299.1	40582.8	39874.6
Mercury	1.7	0.0	0.0
Selenium	768.7	771.1	757.1
Zinc	0.0	7588.5	7456.1
Electric Utilities-New/Coal			
Arsenic	0.0	1794.5	2677.2
Beryllium	0.0	382.3	564.1
Cadmium	0.0	72.6	98.8
Chromium	0.0	855.1	1212.2
Copper	0.0	20432.6	28964.0
Cyanide	0.0	54.2	108.5
Lead	0.0	2374.7	3559.8
Manganese	0.0	22372.2	32200.6
Selenium	0.0	670.6	989.7
Zinc	0.0	6128.3	3687.1
Nuclear			
Copper	79.9	269.4	361.6
Zinc	0.0	66.0	88.6

TABLE LIII

SCENARIO COMPARISON OF NET RESIDUALS DISCHARGES OF SELENIUM TO AIR
(TONS)

Source	1978	National Energy Plan	1985 Baseline	Low Economic Growth	National Energy Plan	1990 Baseline	Low Economic Growth
Copper Smelting	31.0	44.5	43.9	41.4	45.0	46.4	44.0
Electric Utilities							
Old/Coal	404.0	371.3	346.4	355.9	354.7	340.1	349.5
New/Coal	0.0	311.1	301.3	162.4	396.0	444.7	248.3
Industrial Combustion							
Coal	126.5	382.1	173.2	154.1	522.1	215.4	177.5

The minor differences in the release of manganese and beryllium to the air are caused primarily by the differing degrees of coal utilization assumed in the three scenarios. The NEP scenario, with its high coal use assumptions, forecasts greater atmospheric emissions of these two toxics. Conversely, the LEG scenario forecasts greater emissions of nickel to the atmosphere than either the Baseline or NEP scenarios. In this case, slower retirement rates of oil-burning electric utilities and industrial boilers result in relatively more residual oil-burning facilities in existence over the forecast period. Nickel, since it is a trace element of heavy oils, is then passed on to the atmosphere in greater proportions in the LEG scenario.

The primary sources of nickel discharged to water, however, are coal-fired utilities, and greater residuals are therefore generated in the NEP scenario than the Baseline or LEG scenarios.

The purely economic impacts on residuals generation can best be seen in forecasts of chromium discharges to water. The major contributor of this toxic has been identified as the textile industry which experiences significant variations in growth between scenarios. Dollar output by the textile industry is forecast to expand from 1975 to 1985 at a 5.2 percent annual rate in the Baseline, 6.0 percent in the NEP, but only 2.7 percent annual rate in the LEG scenario. Although growth rates are similar over the following five years (1985 to 1990), total output from this sector is 22 percent less under low growth than the Baseline in 1990, thereby accounting for lower discharges of chromium in its effluents. For the same reasons, discharges of phenols to water forecast for 1990 are less in the LEG scenario than the Baseline or NEP scenarios, although differences between scenarios are not as great.

It is clear from this analysis that the economic and energy paths taken in the U.S. will profoundly influence the quantities of toxics released to the environment from industrial and other nonnatural sources. Particularly significant will be the extent to which coal use expands, and the economic conditions which enable industry and utilities to convert their current facilities to more stringently regulated and, in some respects, "cleaner" combustion processes.

APPENDIX A

VALIDATION OF SEAS ESTIMATES

1.0 VALIDATION OF SEAS CRITERIA AIR POLLUTANT ESTIMATES

In support of SEAS air residuals forecasts, the model's base year data have been compared with national emissions estimates from EPA's National Emissions Data System (NEDS).[1] The information, compiled in an annual National Emissions Report (NER),[2] consists of state agency reports of emissions levels recorded by local monitoring stations.

Since the latest version of the NER reported emissions for 1973, some difference may be expected between NEDS and SEAS due to changes occurring between 1973 and 1975. Factors such as the type of fuel being burned by a production process, the sulfur and ash content and heat values of these fuels, and most notably, the extent and type of emission controls being applied changed substantially over this period. Other differences stem from differing methodologies and level of detail. Such cases were examined to isolate the source of major discrepancies, and SEAS information has been amended as appropriate.

1.1 Particulates

Total net particulates are slightly higher in NEDS than in SEAS (16.5 million tons versus 14.5 million tons, but this difference becomes less significant when examined on a sector by sector basis.

Electric utilities are estimated in NEDS to generate 3,570,000 tons, compared to and 3,500,000 tons assumed in SEAS. Although more fuel was consumed in 1975, the differences may be accounted for by improvements in abatement efficiencies. Distribution of particulate emissions among fuel types reveals further agreement between NEDS and SEAS, especially for coal, which is expected to produce over 90 percent of power plant particulates by both NEDS and SEAS (3,455,000 tons in NEDS versus 3,473,000 tons in SEAS).

Gross residuals from industrial combustion were derived for SEAS from EPA's report AP-42[3] and adjusted by EPA's SIP compliance data to yield net amounts. SEAS values in this case are lower than NEDS (1,461,000 tons in SEAS versus 1,928,000 tons in NEDS). This difference may be attributable to cumulative effects of the time factor and possible optimism in compliance data. In addition, NEDS includes emissions from categories such as wood burning and other sources not included in SEAS.

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[1] M. Placet and N. Legget. "A Comparison of National Air Residuals in NEDS and SEAS," February 3, 1978.

[2] 1973 National Emissions Report - National Emission Data System (NEDS) of the Aerometric Emissions Reporting System (AEROS).

[3] Office of Air Quality Planning and Standards, Compilation of Air Pollution Emission Factors, publication AP-42, March 1975.

Particulates from the transportation sector are slightly greater in SEAS, partly due to increased fuel consumption from 1973 to 1975 (1,156,000 tons in NEDS versus 1,176,000 tons in SEAS).

Another major source of particulates is the residential-commercial sector. SEAS data for estimated fuel use in 1975 was supplied by the Federal Energy Administration in 1977 National Energy Outlook, the most recently available source of data concerning the changing fuel mix in these sectors. SEAS estimates are substantially lower than NEDS values for this sector (321,000 tons in SEAS versus 556,000 tons in NEDS). This reflects the difference in natural gas and coal consumption between the two sets of data, as summarized below.

TABLE A-I

RESIDENTIAL AND COMMERCIAL FUEL USE

	NEDS 1973 Fuel Use	Percent of Total	SEAS 1975 Fuel Use	Percent of Total
Natural Gas	10.7×10^{12} ft	70.61	7.2×10^{12} ft	60.50
Oil	29.8×10^{9} gal	27.22	32.7×10^{9} gal	38.04
Coal	15.2×10^{6} tons	2.17	8.02×10^{6} tons	1.46

[1] Percentages were developed by converting the fuel units using the following factors:
Natural gas = 1,032 Btus/ft
Oil = 142,857 Btus/gal
Coal = 11,176 Btus/lb

The energy-consuming sectors discussed above contribute the major portion of particulate residuals (45.0 percent). Analysis of them provides sufficient evidence of the integrity of the SEAS data. Many other industries contributing less significant amounts of particulates were also examined, but are not discussed.

1.2 Sulfur Oxides

Estimates of total net sulfur oxide (SO_x) discharges are fairly consistent between SEAS and NEDS, differing by only 1.2 percent (32,500,000 tons in SEAS versus 32,900,000 tons in NEDS). The slightly smaller Baseline value reflects increased fuel use subject to more stringent controls as well as a greater shift toward combustion fuels.

Examination of SO_x production at the individual sector level also shows concurrence between the two studies in a number of instances. Residential and commercial fuel use emissions, for example, differ by only 0.5 percent. Again the SEAS base year estimates are lower (1,458,600 tons in SEAS versus 1,466,300 tons in NER).

SO_x estimates from electric utilities are 3.3 percent larger in SEAS (22,366,500 tons) than in NEDS (19,386,400 tons). This significant difference may be caused by several factors. The primary change in the inputs to these studies is a rapidly changing fuel mix assumed by the Baseline scenario, in which coal and nuclear power substitute for oil and gas-fired plants. Since utilities are subject only to SIP control requirements for 1975, the changing fuel use between 1973 (NEDS) and 1975 is evident in increased residuals from coal--SO_x from coal utilities is 16.1 percent larger in the Baseline scenario (20,479,000 tons in Baseline case versus 17,176,400 tons in NEDS).

A second area of major differences between SEAS and NEDS is the industrial combustion sector. NEDS contains a 1973 value of 4,580,200 tons SO_x, while the baseline scenario estimates only 3,555,300 tons, a difference of 22.4 percent. Part of this discrepancy is attributable to the higher abatement efficiencies employed in calculating the Technology Assessment Modeling Project (TAMP) baseline estimates, but the NEDS report also includes SO_x from wood and additional fuel sources not included in SEAS. Coal combustion accounts for 2,789,600 tons in NEDS, and 2,674,600 tons in SEAS, reflecting a difference of only 4.1 percent. Oil combustion accounts for most of the difference between scenarios; a difference of 43.9 percent between the two sources. Levels of industrial oil use in the Baseline scenario were examined in light of the DOE monthly Energy Review Data for 1975 (January 1978). The results showed the TAMP value to be consistent with a DOE estimate (5.966 quads in DOE and 5.113 quads in Baseline scenario).

Transportation-related SO_x emissions account for 506,900 tons of emissions in NEDS and 334,700 tons in the Baseline scenario, a difference of 34.0 percent. Whether this is attributable to different energy use assumptions or more fundamental differences cannot be determined since energy consumption figures used to calculate NEDS emissions factors were unavailable.

1.3 Nitrogen Oxides

Comparison of the National Emission Report (NER) estimates with TAMP estimates indicates that overall SEAS values are 6.6 percent lower than NEDS for nitrogen oxide (NO_x) emissions. These differences are broken down in Table A-II. Since NEDS estimates are for 1973 and SEAS values are for 1975, some differences in emissions are expected due to changes in fuel use, fuel heating values, and the extent of emission controls.

Most of the 6.6 percent difference is due to changes in transportation fuel use. SEAS assumes 17.201×10^{15} Btus for transportation, or 5.6 percent less than NEDS. Since transportation accounts for the largest sources of NO_x emissions, the change in fuel use causes a significant variation in the NO_x emissions shown in the table.

SEAS emissions for the industrial combustion of natural gas are based on 175.8 tons NO_x emissions per 10^{12} Btus, assuming one third of industrial natural gas-fuel boilers in the large category, an increase from former estimates. An increase in industrial natural gas combustion by 8.8 percent over 1973 also accounts for the higher NO_x emissions in this sector.

Utility fuels combustion and emissions for SEAS are based on state by state power plant data obtained from the Federal Power Commission for 1975, which is the most complete data available. Differences between 1973 NEDS and 1975 SEAS NO_x emissions reveal fuel switching and increased controls over the period.

1.4 Hydrocarbons

SEAS base year estimates of hydrocarbon emissions disagree with NEDS data with respect to sector emissions over most industrial categories.

Industrial combustion from point sources corresponds well between the reports, if wood and other categories in NEDS that contribute 44,600 tons to the difference are separated. Although the Baseline scenario contains more industrial fuel use (13.3 quads baseline versus 11.9 quads NEDS), the levels of emission control produce lower emissions of coal and natural gas. Total industrial point-source emissions are 50,400 tons in the Baseline case and 60,200 tons in NEDS, discounting wood and other categories.

TABLE A-II

NO_x EMISSIONS

Source	NER Value (1973) 10^3 Tons/Year	TAMP Net Value (1975) 10^3 Tons/Year
Utilities		
Coal	4,632	4,478
Oil	1,088	1,234
Natural Gas	1,181	1,023
Other	62	
Total	6,963	
Industrial Combustion		
Coal	661	758
Oil	667	625
Natural Gas	1,170	1,580
Wood	140	
Other	12	
Total	2,650	
Residential/Commercial		
Coal	56	50
Oil	532	423
Natural Gas	401	372
Wood	24	
Other	<0	
Total	1,014	
Transportation		
Land Vehicles	9,300	
Gas	6,839	3,682 (auto)
Diesel	2,461	2,849 (truck)
Aircraft	155	
Vessels	194	
Gas Handling Equipment	0	
Total	9,649	
Other	1,485	3,258
Total	21,761	20,332

With the exception of the primary metals sector, which varies by only 4.0 percent between scenarios, there is disagreement for most of the remaining hydrocarbon producing sectors. Residential and commercial fuel combustion, for example, exhibit a difference ranging from 40.0 to 18.8 percent, depending upon the exclusion of wood listed as a fuel by NEDS. The National Emission Report contains a total of 187,200 tons, including 5,100 tons from wood. These figures dwarf the 109,800 tons in the baseline scenario. In addition to the difference produced by wood combustion, NEDS displays an additional 36.2 x 10^3 tons from combustion of coal, although the difference in Btus of coal is only 0.02 quads.

Gas handling evaporation losses at service stations, although compatible at 1,193,900 tons in NEDS and 1,007,200 tons in the Baseline case, still differ by 15 percent. This trend of larger evaporation losses by the NEDS report is borne out by a 34.5 percent difference from the Baseline scenario in solvent evaporation losses (point and area). Values of 4,798,000 tons by NEDS produce a 1,656,700 ton difference from the 3,141,300 tons in the Baseline scenario. The validity of comparison is uncertain as the Baseline scenario figure includes aggregation of paints, dry cleaning, and petroleum transportation and printing, whereas information is not yet available about what sectors are included in the NEDS figure.

The HC emissions from chemical manufacturing are a major area of concern. NEDS contains 1,508,300 tons as opposed to 121,100 tons in the TAMP Baseline scenario. This represents a difference of 1,447,200 tons. The major components of this category in NEDS are paint manufacture and carbon black manufacture, with ammonia production, charcoal manufacture, phthalic anhydride production, printing ink manufacture, and nylon production, secondary. The Baseline scenario also contains phthalic anhydride, nylon and carbon black production, and small additional sources, but does not include paint manufacture which accounts for 44,248 tons of the difference between the two reports. A large portion of the remaining difference lies in carbon black manufacture.

Miscellaneous HC sources, such as structural fires, slash burning, frost control, and forest fires, appear in NEDS but not in SEAS, contributing an additional 650,470 tons to the scenario difference.

The value of a comparison between NEDS and SEAS is limited since several vague areas exist. A forthcoming NEDS document containing greater category disaggregation will clarify some of these areas. Work is also underway in several of the major HC contributing sectors listed by SEAS, notably transportation, paints, solvents, dry cleaning, and chemical manufacture, providing answers to present questions.

1.5 Carbon Monoxide

Carbon monoxide (CO) emissions emanate largely from the transportation sector (83 percent in NEDS 1973, 90 percent in SEAS 1975), of which nearly 98 percent (NEDS) originates from land vehicles burning gasoline and diesel fuel. Total national CO emissions estimated by SEAS and NEDS are within 11 percent of each other. Part of this difference is attributable to the different years compared (1973 NEDS, 1975 SEAS), different emission control efficiencies, and different fuel heating values. However, significant disparity exists between "transportation" and "other" estimates of NEDS and SEAS (Table A-III). These disparities tend to cancel each other, resulting in closer total emissions estimates between the two systems.

A lesser problem in comparing CO emissions estimates of NEDS and SEAS is the separation of point and area sources. SEAS generally does not consider area sources except in transportation, but focuses on point-source emissions, while NEDS breaks out both area and point sources. All residential and most commercial emissions are considered area sources in NEDS, resulting in much lower residential and commercial point-source estimates than developed by SEAS.

Other unresolved problems are CO emissions from chemical manufacturing, primary metal industry, petroleum refining, and municipal incineration. These categories are largely responsible for the differences between NEDS and SEAS estimates in the "Other" category shown in the table.

For the industrial combustion sector, differences between NEDS and SEAS emissions for coal, oil, and natural gas are due primarily to increased pollution control efficiencies.

TABLE A-III

COMPARISON OF SEAS BASE YEAR ESTIMATES OF CO EMISSIONS WITH NEDS

	1973 NEDS (Point Source Only) 10^3 Tons/Year	1975 TAMP 10^3 Tons/Year
Electric Utilities		
Coal	193	222
Oil	44 (with diesel)	59
Natural Gas	39	25
Other	1	
Total	278	306
Industrial Combustion		
Coal	42	38
Oil	36	34
Natural Gas	123	74
Wood	207	
Other	20	
Total	428	146
Residential/Commercial		
Coal	4	83
Oil	2	81
Natural Gas	4	83
Wood	1	
Total	10	248
Transportation		
Land Vehicles	74,058	
Gas	73,003	60,782 (auto)
Diesel	1,055	30,297 (truck)
Aircraft	836	251 (passenger)
Vessels	1,084	
Gas Handling Equipment	0	
Total	75,977	91,330
Other	14,534	9,226
Total	91,227	101,257

2.0 VALIDATION OF SEAS CONVENTIONAL WATER RESIDUALS ESTIMATES

This section attempts to validate SEAS conventional water residuals forecasts by comparing the system's base year data with those of other sources. Although many sources of water pollution generation coefficients and measures of polluting activities are available, few of those identified have proven to be completely independent of the SEAS data base and are, therefore, unsuitable for meaningful comparisons. As a result, the primary source of information used to compare SEAS residuals estimates is the data base developed by the National Accounting and the Environment (NAE) project.[1] These data, although they fail to provide the degree of comparability characteristic of the NEDS data base, provide reasonable estimates of industrial effluent discharges which can be both qualitatively and quantitatively compared to SEAS estimates.

2.1 Dissolved Solids

Consistency problems prevent a thorough comparison of dissolved solids estimates by SEAS and the NAE data base. In the aggregate, SEAS estimates of total dissolved solids are nearly an order of magnitude less than the discharges estimated by NAE. This is partly attributable to several apparent "holes" in SEAS water residuals data, the different years upon which the data are based, and differences in assumed sectoral composition.

Several industrial sectors found to be significant dischargers of dissolved solids in the NAE data base are not represented in SEAS. These include mining (other than coal) 46.5 million tons; municipal sewage; 16 million tons; oil and gas extraction, 8 million tons; and fertilizers, 3 million tons.

Even for those sectors where SEAS and NAE are comparable, large differences remain. SEAS estimates net dissolved solids discharges from the organic chemicals industry to be 8 million tons in 1975; NAE estimates the same industry to discharge 23 million tons in 1972. Similar comparisons are shown in the table below.

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[1] Data taken from L.P. Gianessi and H.M. Peskin, A Comparison of Recent National Estimates, Resources for the Future, Discussion Paper D-2, Washington, DC, February 1977.

TABLE A-IV

COMPARISON OF SEAS AND NAE DISSOLVED SOLIDS DISCHARGES FOR SELECTED INDUSTRIAL SECTORS (MILLIONS OF TONS)

Sector	SEAS Net Discharges (1975)	NAE Estimates (1972)
Organic Chemicals	8,060	23,400
Coal Mining	2,420	684
Inorganic Chemicals	1,460	22,100
Electric Utilities	6,220	12,150
Feed Lots	----*	19,950

*Trace (approximately 80 tons).

A comparison between the two sources reveals significant disagreement, although little evidence is available to indicate which estimates are closer to reality. Given the information gaps found in the SEAS data, dissolved solids seem likely to be significantly underestimated by SEAS in the base year (1975) and throughout the forecast period. However, given industrial compliance with effluent regulations, the degree of underestimation is likely to be significantly less than the order of magnitude seen in the 1973-1975 comparison.

2.2 Suspended Solids

Significant disagreement exists between SEAS and NAE estimates of suspended solids. This difference is almost entirely due to apparent gaps in the SEAS data base. Ore and mineral mining activities produce nearly 50 million tons of suspended solids annually according to NAE; SEAS does not allow for discharges from these sectors. Mines are recognized as a primary source of both dissolved and suspended solids.[1]

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[1] U.S. Environmental Protection Agency, Quality Criteria for Water, EPA-440/9-76-023, Washington, DC, p. 27, 71.

The major sectoral contributors of suspended solids identified in SEAS are municipal sewage and incineration, aluminum, pulp and paper, textiles, steel, and asphalt. Comparisons of SEAS estimates with those of NAE are shown in Table A-V.

TABLE A-V

COMPARISON OF SEAS AND NAE SUSPENDED SOLIDS
DISCHARGES FOR SELECTED INDUSTRIAL SECTORS
(MILLIONS OF TONS)

	SEAS		NAE	
Sector	SS Discharges	Percent of Total	SS[1] Discharges	Percent of Total
Municipal Sewage	1,474	20	3,000	20
Aluminum	1,144	16	11	----
Pulp and Paper	1,105	15	1,040	7
Textiles	992	14	65	<1
Steel	950	13	662	4
Asphalt	536	7	793	5
Other	1,093	15	9,318	62
Total	7,295	100	14,889	100

[1] Excluding discharges from mining activity, drinking water, and steam supply.

2.3 Oil and Grease

Oil and grease estimates by SEAS and NAE are reasonably consistent. NAE estimates total effluent discharges from industrial activity to be approximately 971,000 tons in 1972. SEAS calculates almost 2,500,000 tons discharged in 1975. Although the difference is large, the two estimates are within reasonable agreement given the problems associated with comparing the two sources.

Major industrial dischargers and their relative contributions to the total waste load are shown in Table A-VI. The major difference between data bases relates to estimated oil and grease discharges from the organic chemicals industry. Even if different definitional conventions used to map industries into industrial sectors are considered, the NAE still estimates far less than SEAS. However, different conventions may account for the variance in estimates in the petroleum refining and storage and the meat products processing industries, although relative contributions of discharges are reasonably close. Beyond the problems with defining the chemicals and petroleum processing industries, the only apparent gaps in SEAS are with respect to miscellaneous foods and beverages and municipal sewage.

2.4 Biochemical Oxygen Demand

A comparison of SEAS and NAE estimates of discharges of biochemical oxygen demand (BOD) reveals most sectoral estimates to be in reasonably close agreement, given the structural differences in data bases described earlier. Total discharges of BOD estimated in the NAE study are roughly double the quantity estimated by SEAS. The lower SEAS values may reflect higher secondary sewage treatment rates possibly achieved in 1975. CEQ data[1] reveal a gradual decline in average violation rates with respect to BOD (the percentage of times BOD levels exceed a prescribed benchmark level) throughout the years 1968 to 1976, which can be attributed to the installation of more effective sewage treatment systems. SEAS data for discharges of BOD from sewage treatment plants reflect this trend.

A comparison of SEAS and NAE estimates for selected industrial sectors is shown in Table A-VI. Although absolute differences between estimates remain, the relative contributions of the two major dischargers are consistent between data sources.

2.5 Chemical Oxygen Demand

Unlike the other conventional water pollutants examined in this section, no estimates of chemical oxygen demand (COD) discharges from point sources outside of the SEAS data base are available for comparative purposes. However, some assessment can be made on an industry by industry basis.

COD has been cited as a significant residual in the wastewater of textile mills;[2] however, its concentrations in these effluents are not well documented. The Cost of Clean Water has estimated total COD discharges from textile mills to be 340,000 tons in 1972. In sharp contrast, SEAS indicates a 9,703,000 ton net discharge in 1975. The estimates thus differ by more than an order of magnitude.

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[1] Council on Environmental Quality, Environmental Quality-1977, Executive Office of the President, U.S. GPO, Washington, D.C., December 1977, p. 211.

[2] U.S. Environmental Protection Agency, Development Document for Effluent Limitations Guidelines and New Source Performance Standards for the Textile Point-Source Category, Effluent Guidelines Division, Office of Water and Hazardous Materials, Washington, DC, June 1974.

TABLE A-VI

COMPARISON OF SEAS AND NAE DISCHARGES OF OIL AND GREASE FOR SELECTED INDUSTRIAL SECTORS (THOUSANDS OF TONS)

	SEAS		NAE	
Sector	Discharge	Contribution (Percent)	Discharge	Contribution (Percent)
Organic Chemicals	1,935	80	177	18
Steel	212	9	299	31
Petroleum Refining & Storage	198	8	46	5
Meat Products Processing	65	3	10	1
Inorganic Chemicals	NE	---	13	1
Phosphates	NE	---	46	5
Seafoods	2	0	10	1
Textiles	17	1	18	2
Miscellaneous Chemicals	NE	---	77	8
Misc., Foods & Beverage	NE	---	62	6
Oil and Gas Extraction	NE	---	48	5
Municipal Sewage	NE	---	97	10
Other	64	3	69	7
Total	2,493	100	971	100

NE = no estimate